DISTINCTIVE FEATURE ANALYSIS OF KANNADA CONSONANTS

C.S. Venkatesh
Reg No. 11

A DISSERTATION SUBMITTED IN PART
FULFILMENT FOR THE DEGREE OF MASTER OF SCIENCE
(SPEECH AND HEARING)
UNIVERSITY OF MYSORE

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DEDICATED

TO MY

BELOVED

FATHER AND MOTHER

CERTIFICATE

This is to certify that the Dissertation entitled - 'Distinctive Feature Analysis of Kannada Consonants' is the bonafide work on part fulfilment for degree of M.SC, Speech and Hearing of the student with the Register Number Eleven (11).

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CERTIFICATE

This is to certify that this Dissertation entitled 'Distinctive Feature Analysis of Kannada Consonants' has been prepared under my Supervision and guidance.

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DECLARATION

I hereby declare that this dissertation entitled 'Distinctive Feature Analysis of Kannada Consonants' is the result of my own study undertaken under the guidance of Mr. N.P.Nataraja, Lecturer and the incharge Head of the Department of Speech Pathology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other diploma or degree.

Register Number,
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CONTENTS

CHAPTER I

INTRODUCTION

The language has several levels, like semantic, syntactic, morphemic, and phonemic levels. The 'phonemic' level is the lowest and most fundamental level. "The sound pattern of a given language is fundamental to its structure" (Danioloff et al 1980). Untill recently, speech scientists and linguists were of the opinion that the "phoneme' is the basic unit of speech, till Jokobson, Fant and Halle proposed a set of universal feature system in 1951. Now features are the basic units of speech. The features which provide inherent distinctions between speech sounds are called distinctive features.

"As human beings we have ability to detect and categorize features. With out these skills, we could not observe consistencies among events that might otherwise appear unrelated. The early cognitive growth of young children heavily depends on decisions that involve features. Those features that become important are regarded as distinctive......" (Singh, 1976).

Language is built up of words, words of sounds or phonemes and phonemes of features which are distinctive from each other. A explicitly simple sound is thus composed of several parameters, which can be seen in the form of features, which describe it. Those features which provide the information, about various distinctions between these speech sounds are called 'distinctive features' In essence the distinctive features can be thus referred to as "building blocks of phoneme". The speech scientists are interested not only in the combination of various features in the phoneme but also in the way each of these "features" are acquired, maintained and lost during pathology.

"The 'Distinctive features' of an individual phoneme would be those aspects of the process of articulation and their acoustic consequences that serve to contrast one phoneme with others" (Berko and Brown, 1960).

Articulation disorders have a relatively new vista opened to them. Speech scientists have been regarding misartlculation as a form of "distinctive feature deviation' (Singh, 1972). Distinctive feature approach is now being applied to speech, pathology in the process of diagnosis, testing and treatment.

A distinctive feature system is an organized system of the phonemes in a language and each feature having two mutually exclusive values. A complete feature system is the one which distinguishes all the phonemes of the language from each other.

Various approachs have been reported to study these distinctive features. They are:

1. Acoustic method
2. Articulatory method.
3. Perceptual method.

Acoustic method identifies features by the following acoustic clues.

1. Voice onset time.
2. Transition of formant
3. Concentration, locus and duration of energy.

Articulatory method uses phonetic descriptions of the sounds to define destinguisting qualities of speech sounds.

The perceptual method requires the study of the perceptual responses to the sounds by the listeners.

The establishment of feature system on a particular language can be done by either by 'Apriori' or 'Aposteriori' method. Miller and Nicely (1955) define the 'apriori' method as "defining or proposing a system before the articulatory or acoustic or perceptual analysis is done. This method lacks flexibility but is less time consuming than the 'Aposteriori' method. In the 'Aposteriori" method, a large sample is taken and analyzed by various techniques.

Various studies show that the concept of distinctive feature analysis is avaluable in the management of articulation disorders. (Haas, 1963; Weber, 1970)Pompton, 1970; Mc Reynold and Huston, 1971; Pollack and Rees, 1972;

Mc Reynold and Bennet, 1972; Singh and Rrank, 1972... etc). Many investigators state that the multifaceted advantages of distinctive features and economy to be the mo significant factors among them.

The horisones of the realem of speech perception have been broadened by the feature approach. The feature analysis as compared with the sound analysis provides multidimentional information about speech sound perception. Many studies have been done in the hard of hearing population regarding their perceptual abilities (Binnie, Montgomeny and Jackson, 1974; Danhami et al, 1978; Doyle et al 1981). Recently linguistic evidence has also been she for some features %i.e. encoded features are processed in the left hemisphere for right handed individuals. (Studert, Kennedy and Shankeoeler, 1970; Hayden etal, 1979; .... etc.)

Need for present study

Speech pathology deals with the understanding and treatment of speech language disorders. This necessitates a good understanding of the case who has the problem and in addition the language to be taught. The situation in India, with its multiplicity of linguistic groups, necessitates the study of language. Present additional problems is that the speech clinician may have to work with languages non-native to him" (Somasundaran,1972).

This clearly necessitates the need for the distinctive feature analysis in different languages and hence in Kannada.

458 minimal pairs were made using the 31 phonemes of Kannada and were randomly presented in a quite situation to 30 Kannada listeners and 30 non-Kannada listeners using a tape recorder. Their responses were recorded and analysis was done by the experimenter. Later confusion matrices were constructed for the 2 groups. Information content of each feature was determined.

Spectrographic analysis for 74 words were done and acoustic characteristics were detected

Statment of the Problem:

This study has carried out to explore, the possible existence of distinctive feature system for consonants in Kannada by the perceptual and acoustic methods respectively

Hypotheses:-

1. Kannada language has a distinctive feature system
2. It is possible to propose a distinctive feature system in Kannada based on phonetic description.
3. Consonants in Kannada are made up of the following features.

   a) Voicing b) Nasality c) Continuent
   d) Anterior e) Coronal f) stridency
   g) Aspiration h) lateral.

4. Information value carried by each feature varies.
5. Each feature has a distinctive acoustic characteristic.
6. No significant difference will be found in the listening performance of Kannada and non-Kannada speakers when word with minimal differences are presented in a quite situation.

Limitations of the Present study:-

1. Distinctive feature system has been proposed only for consonants.
2. Only experimenter served as the judge in the present study.
3. Only 30 listeners were used in each of the groups
4. Apriori analysis has been used.

CHAPTER II

REVIEW OF LITERATURE

Language is primarily encoded as speech and it is the most common means of communication, (Trwin and Marge). Language is a system, composed of sounds arranged in ordered sequences to form words and morphemes, and the rules for connecting these elements into sequences or strings that express thoughts, intention, experience and feelings. Thus language is made up of phonological morphological, syntactic, and semantic components, which must be learned, to understand and speak a given language (Chomsky 1957). These components are hierarchical in nature and the lowest component is'the phonological system'. The study of phonemes is important to understand a language system

Till 1939, it was believed that a phoneme is the smallest unit of language and that can not be further divided. In 1939 a new theory propsed that the basic unit of phoneme is, its constituent properties. Thus theory was put forward by 'ROMAN JAKOBSON' through his book "child language, Aphasia and phonological universals" (1941) which was originaly in German and translated to English in 1968 by 'Allan Keiler'. But the real introduction of distinctive feature theory took place through another book "Priliminaries to speech Analysis: The Distinctive Eeatures and their correlates (Jakobson, Fant

Fant and Halle, 1952) which was originally published in English.

The parameters or the constituent properties of the phoneme are called "Features". The parameters which distinguish two phonemes of a language are known as "distinctive features".

According to Jakobson, Fant and Halle (1952) the distinctive features are the ultimate distinctive entities of language. The distinctive features combine into one simultaneous or concurrent bundle to form a phoneme.

Jakobson (1962) has explained the distinctive features by giving an anology between the musical chords, the phoneme and the distinctive features. This model has the opasity to represent the phoneme as one unit - the chord itself, and notes as the variety of components which are comparable to the features, a variety of motorically produced acoustic properties. A chord is heard as one eliment, eventhough it is made-up of many components. Hence, eventhough the phoneme is heard as one unit, it consists of many features, e

Fant (1973) defines it as real distinctive categories or class within a linguistic system, but just like in accepted phoneAic analysis it is required that they are consistant with the phonetic facts and these phonetic facts at various levels have bent their name to the features.

Singh (1975) defines distinctive features as the physical (articulatory or acoustic) and psychological (perceptual) realities of the phonemes. Each phoneme can be described and differentiated interms of (1) articulatory features, namely the place of articulation and the manner of articulation (2) Acoustic features, namely frequency intensity and duration of speech sounds, and (3) perceptual features which are the result of the auditory discrimination between the phonemes.

Blache (1978) defines a distinctive feature as systemic property that seperates a subset of elements from a group.

The distinctive feature systems have been proposed by several people. The most frequently used systems are those proposed, by

1. Jakobson et al (1952) who have used "Phonemic Theory" to derive distinctive feature system;
2. Chomsky and Halle (1968); have used "Generative theory" to develop distinctive feature system.

According to phonemic theqry there are two levels of phonological structure.

(a) an abstract phonemic level

(b) a phonetic level (speech signal)

Distinctive features are qualities contained in the speech signal itself that are necessary for the speaker-hearer to identify the phonemes of his language. This identification is made by picking out concurrent groups of these features and interpreting each group as a particular phoneme. If the phonemes of a language are made of distinction features than the allophones of that language are made of distinctive and non distinctive features. That is within the phonemic theory, distinctive features, are taken to be all an only those features necessary to distinguish each phoneme in given language from other phonemes of the language.

Phonemes are significant abstract segments of a particular language. If one assumes the phonemic position as that distinctive features are the eliments of phonemes, then this allows for the possibility of having language specific distinctive features.

Thus theory postulates relationship between the phonetic and phonemic level of representation.

(a) Every phoneme in the phonemic level can be represented by at least one phone in the phonetic level.

(b) Phones at the phonetic level must be in the same order as the phonemes as they correspond to at the phonemic level.

However, at all levels there is no one to one relationship between the phonetic and phonemic levels of represention.

Phonemic theory of bi uniqueness states that there must be an unique representation for each phonetic sequence and unique phonetic representation for each phonemic sequence. Here the phonetic context is taken into consideration.

Some of the implications that phonemic theory has for distinctive features are:

1. Phonemic theory implies the existence of non-distinctive features, which not only adds unncessary formal apparatus to the theory and makes the set of distinctive features potentially infinite, but also the concept of non-distinctive features is not precisely definable.

2. It allows for the posibility of language specific distinctive features, which makes comparisons among different languages in terms of distinctive feature impossible.

3. It imposes the condition of linearity and biuniqueness on the relation between the phonemic and phonetic levels of representation, eventhough these conditions can be shown not to hold.

4. "The assumptions on which the tenets of phonemic theory are based are not valid; namely that there is a direct correspondence between phonemes and what speakers actually produce and hear in speech" (Parker 1976).

Thus in conclusion it can be stated that these is a significant discripancy between the physical signal and the way it is percieved. It would seem that instead of directly interpreting the sound waves that stimulate the ear, the speaker hearer interprets them interms of the complex, abstract linguistic system that constitutes his knowledge of his language.

Generative theory derived from the phonemic theory proposes a different concept of phonology (Chomsky and Halle 1968),

Chomsky and Halle (1968) in their theory excluded the one to one relation-ship between phonological segments and speech segments. Since these there is no theory of phonemies operating in generative phonology. It is based on a system of universal phonetics. Chomsky and Halle (1968) state that the features are identical with the set of phonetic properties that can be in principle controlled in speech, representing the phonetic capabilities of man and therefore the same for all languages. Limiting the distinctive features to phonetic properties that are independently controllable speech makes the selection of distinctive features emphirical than arbitary.

This theory has made an attempt to account for the type of phonological variation that exists between phonetics and abstract forms. Chomsky and Halle (1968) have recognized two abstract levels of phonological structure (a) a more abstract "classificatory Matrix" (b) a less abstract one "phonetic matrix". A quality/parameter that is never significant in any natural language, need not be specified in the phonetic matrix. The classificatory and phonetic matrix of any given utterance may differ radically in terms of number of segments and the feature specification of each segment necessitates a method of transfering one into the other. Chomsky and Halle (1968) propose an ordered set of context sensitive phonological rules that alter the feature specifications of the classificatory matrix to yield the phonetic matrix and vice versa.

Parket (1976) states that distinctive features as they are described in generative pholology are not components of speech production. He suggests a production matrix, below the phonetic matrix in which distinctive features are translated into parameters of speech production.

The distinctive feature concept is based on principles of (a) Binary scale and (b) Economy, i.e. the binary principle basically considers the presence or absence of a particular feature. The use of binary scale has been found to be very useful. Some experiments have shown that the analysis of any event by human beings is based on binary principles. Use of binary scale helps in the analysis of speech data by computers. The principle of economy is used to minimize the redundency that is seen in the language, thus simplifying the process of describing the language.

Various functions of distinctive feature are :

1. Description of phonemes.
2. Description of the interrelationships between the different phonemes of a language and also allophonic variotions.
3. Quantification of these interrelationships
4. Classification of phoneme depending upon the distinction i.e. of a group of phonemes share a large number of features then they form a natural class and if a group of phonemes share a few commodalities they belong to an unnatural class.
5. Finding out the distance between phonemes.and thus in assessing the seventy of articulation disorders.
6. In developing articulation tests in a given language.
7. In preparing and administering therapy for cases with articulation disorders.

Various distinctive features systems to describe the sounds of languages, have been developed. As stated earlier speech sounds are the bundle of series of distinctive features. The basis of these feature codes may be articulatory, perceptual, or acoustic. Usually, the vowels and

and consonants have different distinctive features, because the production and perception of consonants and vowels have different bases. Because of some basic important differences between vowels. and consonants, vowels, are rarely replaced by vowels and vice versa. There are however, some feature systems that describe vowels and consonants interms of the same set of features. Even in these cases, it is seen clearly that the individual features of vowels and consonants do not apply to each other in any significant way (Chomsky and Halle 1968). Some of the important consonant feature systems are given below.

1. Jakobson, Fant, and Halle (1951) :- The base for their work was the system of sounds, and the evidence was presented in terms of acoustic characteristics, using the spectrographic representation of sounds. After studying the acoustic distinctions of phoneme pair, they presented articulatory basis of their acoustic findings. They studied many languages and found distinctive feature is universally applicable.

They concluded that the distinctive features which they detected in the languages of the world and which underlie their entire larical and morphological stock amount to twelve binary oppositions. No one language contains all of these features. They have presented both acoustic and genetic description of each features.

1. Vbcalic/Non Vocalic

Presence (Vs absence) of a sharply defined formant structure. Primary or ordinary excitation of the glottis together with a free passage through the vocal tract.

2. Consonantal/Non-consonantal

Low (Vs high)(total) energy. Presence (Vs absence) of an obstruction in the the vocal tract.

3. Compact/Diffuse

Higher (Vs lower) concentration of energy in a relative narrow, central region of the spectrum, accompanied by an increase (Vs decrease) of total amount of energy and its speread in time.

Forward - flanged (Vs backward-flanged). The difference lies in the relation between the shape and volume of the resonance chamber in front of the narrowest stricture and behind this stricture. The resonator of the forward - flange phonemes (wide vowels, and velar and palatal, including past alveolar consonants) has a shape of a horn, whereas the backward flanged phonemes (narrow vowels, and labials and dentals, including alveolar consonants) have a cavity that approximates a Helmholtz resonator.

4. Grave/Acute:

Concentration of energy in the lower (Vs upper) frequencies of the spectrum.

Peripheral (Vs Medial) peripheral phonemes (velar and labial) have an ample and less compartmented resonator than the corresponding medial phonemes (palatel and dental).

5. Flat/Plain.

Flat phonemes are opposed to the corresponding plain ones by a downward shift or weakening of some of their upper frequency components.

The former (narrowed slit) phonemes, in contradistinction to the later (wider slit)phonemes, are produced with a decreased back or front orifice of the mouth resonator, and concomitant valorization expanding the mouth resonator.

6. Nasal/oral

Spreading the energy over wider (Vs narrower) frequency regions by a reduction in the intensity of certain (primarily first) formants and introduction of additional (nasal) formant Mouth resonator supplemented by the nose cavity versus the exclusion of the nosal resonator.

7. Tense/Lax

More (Vs less) sharply defined resonance regions in the spectrum, accompanied by an increase (Vs decrease) of the total amount of energy and its spread in time.
Greater (Vs smaller) deformation of the vocal tract away from its rest position. The role of muscular strain, affecting the tongue, the walls of the vocal tract on glottis,

requires further investigation.

8. <u>Interrupted/continuant:</u>

Silence (at least in the frequency range above the vocal cord vibration) followed and/or preceded by a spread of energy over a wide frequency region (either as a brust or as a rapid transition of vowel formants versus absence of abrupt transition between sound and "silence").
Rapid turning on and off of source either through a rapid closure and/or opening of vocal tract that distinguishes plosives from constrictives or through one or more tops that differentiate the discontinuous liquids like a flap or trill /r/ from continuant liquids or the lateral /I/.

9. <u>Strident /Mellow</u>

Higher intensity noise versus lower intensity noise. Rough edged (Vs smooth endged). Supplementary obstruction creating edge effects, at the point of articulation distinguishes the production of the rough edged phonemes from the less complex empediment in their smooth edged conterparts.

10. <u>Checked/unchecked</u>

Abrupt decay is opposite of smooth one. The air stream is checked by the compression or closure of the glottis.

11. Sharp/plain

Slight raise of the second formant and to some degree also of higher formants. Oral cavity reduced by raising a part of the tongue against the palate.

2. Miller and Nicely (1955) have described 16 consonants of English using a 5 feature system consisting of voicing, duration, affrication, place and nasality. They denoted each consonant by the presence or absence of a feature. They have not left any consonant unspecified interms of either having or not having a feature. They disregarded this concept of phonological redundancey of a feature for a group of consonants. They relied heavily on the actual phonetic elements of the consonants. They designated '1' to a consonant having a feature and '0' to a consonant having a feature. The basis of their feature system was the inspection of &17' different "Confusion matrices", and the errors made by listeners in identifying the 16 different consonants.

This system represents a significant departure from Jakobson, Fant and Halle (1951) feature system Miller and Nicely (1855) proposed a trinary feature: place of articulation. The feature system proposed by them was a perceptual fe ture system. The basis for choosing the features and their given specifications was somewhat arbitrary. The proposed features were five, out of that four are articulatory and one acoustic in nature. They are:

1. Voicing:- The voiced consonants are produced with vibration of the vocal folds. The voiceless consonants are produced with-out vibration of vocal cords. In acoustic terms, the voiceless consonants are more noisy than the voiced.

2. Duration:- Fricatives have this feature, which seperates them from other sounds.

3. Affrication:- If the closure is such that at the point of contact air is forced through a narrow aperture; the result is a kind of turbulence or friction noise which is known as Affrication.

4. Nasality:- The nasal consonants are produced by opening the naso-pharyngeal port and releasing the intraoral air pressure through the nose.

5. Place of Articulation:- The three different specifications for the place of articulation feature are front, mid, and bach depending upon the place of articulation.

3. Chomsky and Halle (1968):

They provided elaborate phonological grounds for extracting a set of articulatory distinctive features. The stated that, the phonological components from a system of rules that relate to the phonetic r presentation of the sounds of a language. They extracted distinctive features by examining different Hierarchies, of the linguistic rules. They assured that the configurations of the human vocal mechanism and the speech reception mechanism are identical for allmen. These features are based on the phonetic or the articulatory possibilities of man. Each feature is binary an is defined by antonymous adjectives.

There are five major categories in this universal phonetic features. They are (1) major class features (2) cavity features (3) manner of articulation features (4) Source features (5) prosodic features.

1. Major class features:-

(a) Consonantal /Nonconsonantal: The consonantal sounds as produced with obstruction somewhere in the vocal tract, and the non-consonantal sounds are produced with out such obstruction.

(b) Vocalic/Non-vocalic:- Vocalic sounds are produced only when the most radial constriction in the oral cavity does not exceed that in the vowels /i/ and /u/, and when the vocal cords are positioned to produce "spontaneous voicing".

(c) Sonorant/Non-sonarant: Sonarants are produced with "spontaneous voicing".

2. Cavity features:-

(a) Coronal/Non-coronal:- Coronoal sounds are produced with the blades of the tongue raised from its neutral position and non coronal sounds are produced with the blade of the tongue in the neutral position.

(b) Anterior/Non-anterior - All front sounds are called anterior and all back sounds are called non-anterior.

(c) Tongue body features:- The three features high/non-high; low/non low; and back/and non back, relate to the position of the body of the tongue. All these projections of the tongue are measured from its neutral position.

(d) Round/non-round:- Rounded sounds are produced with the rounding of lips from oval or round variable shapes depending on the amount of rounding needed for the production of a given phoneme.

(e) Distributed/Non-distributed: - Distributed consonants are produced with a constriction, that extends for a considerable distance along the direction of the air flow; non-distributed sounds are produced with constriction that extends only for a short distance in this directions.

(f) Covered/Noncovered:- is restricted only to vowels.

(g) Glottal constriction: These sounds are produced by the constriction of the glottal area.

(h) Nasal/Non-nasal:- Nasals are produced with the velum lowered; whereas non-nasals are produced with velum raised.

(i) Lateral/Non lateral:- Lateral consonants are produced by lowering the midsection of the tongue.

3. Manner of Articulation Features:-

(a) Continuant/non-continuant (stop):- The continuant consonants are produced with the constriction in the vocal tract regulated in such a way that complete closure of the air passage never occurs. The non-continuants are produced with complete closure of the vocal tract, so that the passage of air is blacked effectively.

(b) Release Feature:- The plosives (stops) are released intenstaneously - they have release features and affricates which are released with some delay and have non-release feature.

(c) Tense/Non tense:- The consonants that are voiceless are tense and that are voiced are nontense (lax).

4. Source Features:

(a) Voiced/Voiceless:- In the production of the voiced consonants, the vocal folds vibrate, and in the production of voiceless consonants they do not vibrate.

Table 1: Comparison of Distinctive features given by different authors.

	Jacobson Fant & Halle (1951)	Miller & Nicely (1956)	Halle (1964)	Singh & Black (1966)	Wickerlgren (1967)	Chomsky & Halle (1968	Inscdal
Defination of of phoneme	Acoustic	Perceptual	-	Perceptual		Articulated	
Classification	Binary	Trinary	Binary	Binary	two-Binary one-trinary one-with 5	Binary	Binary
No. of features	12	5	8	7	4	5 Categories	5
No.of consonants	21	16	18	21	22	all possible	22
Nasality	+	+	+	+	+	+	+
Place of articulation	Back/front	front mid back		4 categories	5 categories		
Vocalic	+	-	+	-	-	+	-
Consonantal	+	-	+	-	-	+	-
Continuency	+	-	+	-	+	+	-
Openess	-	-	-	-	+	-	-
Afflication	-	+	-	-	-	-	-
Sonorant	-	-	-	-	-	+	-

Conted...

Contd..Table 1: Comparison of Distinctive features given by different authors.

	Jacobson Fant & Halle (1951)	Miller & Nicely (1956)	Halle (1964)	Singh & Black (1966)	Wickerlgren (1967)	Chomsky & Halle (1968)	Inscal
Stridency	+	-	+	-		+	-
Voicing	+	+	+	+	+	+	+
duration	-	+	-	+	+	-	-
high/back	-	-	-	-	-	+	-
Liquid	-	-	-	+	+	-	-
Glide	-	-	-	-	+	-	-
Retroflex	-	-	-	-	+	-	-
Compact	+	-	-	-	-	+	-
Coronal	-	-	-	-	-	+	-
Sibilant	-	-	-	-	-	-	-
Low	-	-	-	-	-	+	-
Grave	+	-	+	-	-	-	-
Tense	+	-	-	-	-	+	-

(b) Strident/Non strident:- Strident sounds are marked acoustically by greater noisiness than their non-strident counterparts. Thus various systems of distinctive features have been proposed and used in the analysis of various languages. Each have their own merits and demerits.

From review, it is evident that, distinctive reatures form the basis of phoneme production and phoneme perception. The problems associated with phoneme production and perception may be due to the mis-use of distinctive features. When the distinctive feature is misused in terms of phoneme production it would lead to defective articulation.

Earlier, speech pathologist employed phonemic analysis to discribe articulation problems. They classify the errors into substitution, distortion, omission, and additions. Now attempts have been made to apply distinctive feature systems to articulatory behaviour of normal and abnormal speakers in terms of articulation. Because of this, the description of the articulatory behaviour, became more detailed and precise.

Haas (1963) studied the articulatory behaviour of a six and a half year old dyslexic boy. He found that the features (plosives, sibilants, nasal, liquid, and -

place of articulation) accounted for the misarticulations and concluded that the important factor in teaching speech sounds is discrimination of these features that the child fails to produce.

Elbert et al (1967) found that transfer of training for consonants was present when two phoneme shared more features. If the phonemes were far apart in terms of features the transfer did not take place.

Crocker (1969)) states that childs' consonantal phonological competence is based on distinctive feature models. He stressed the orderly and systematic nature of child's competence throughout its emergence. He suggested that the child does not learn phonemes or features but new rules for combining features and classes of features. The model does not support the view that one sound is learned from another. It states that a feature is taken from an established feature sound and combined with another feature to establish a new feature sets or sounds.

A 'set' is defined as the complex combination of features that make_up a phoneme. Crocker (1969) reviewed the concept that the development is undifferentiated from general level bo specific level. Normal and deviant articulation can be explained by this model. A sound may be misarticulated because of the complex combination of features that the sounds required for its mastery. This may be because certain critical features were not mastered earlier in development or because the sound was confused with on whose features appeared earlier in a feature set.

Weber (1970) studied articulatory behaviour of 18 subjects with misarticulation using features (place of articulation; manner of articulation and voicing). He found that a set of abnormal rales governs the deviant - articulation behaviour. He found six sets of rules as being used by these cases with misarticulation.

He also established therapeutic strategy aiming at teaching features rather than individual consonants. The treatment was based on two principles. 1) To teach either the entire pattern or category. 2) To teach the child to con trast correct feature with incorrect feature throughout all the stages of therapy.

Compton (1970) analysed substitutions in the articulatory behaviour and demonstrated that the patterns underlying misarticulation stems from small number of underlying phonological principles. These principles are the core of deviant articulation and therapy should be directed towards modifying these underlying rules. He emphasized the role of distinctive features in articulatory; acquisition deviation and correction.

Mc.Reynolds and Huston (1971) analysed misarticulations of 10 children and provided on index to quantify feature errors. This index was computed by dividing the number of correct usage of feature by number of occurrence of feature in the test situation. They felt that application of distinctive features for diagnosis and therapy in articulation disorders is both economical and efficient. Economical, because teaching one feature corrects all the phonemes containing that feature. Efficient because, distinctive features are the vehicles for phonological analysis, and these provide basic elemental unit train rather than training many phonemes. Moreover, feature approach gives precision in articulation training program, by dividing the errors into two groups; (a) Errors due to omission of features, (b) Errors due to inappropriate usage of features.

"More intelligent clinical managements of deviated articulation is possible, through distinctive feature analysis". A phonological analysis of a child's speech with defective articulation was done by Mc Reynolds and Huston (1971) at 3 intervals of age; and the analysis at each age was compared with adult model to reveal the rules of child's phonological competance. The results indicated the way in which the system changed, maintaining in internal order, but gradually approximating that of the adult model. The study indicated that distinctive features offer a base for measuring the severity of a child's articulation problem, measuring progress in articulatory skill, accounting for varying degrees of intelligibility among speakers with defective articulation, recommending therapy and planing and implimenting the therapy program. The distinctinctive features can be used to predict intelligibility of speech also. The intelligibility of speech depends upon:

1) The importance of the feature used and misused in carrying information in a particular language.

2) The number of features used and misused.

The distinctive feature approach may be initially time consuming, but it brings about better understanding of the problem (Pollack and Rees; 1972).

Mc Reynolds and Bennett (1972) have discussed the generalization of features across phonemes. Three children were taken for feature training in the context of nonsense words; first at initial, and then at the final position. The training was given in programmed steps. The steps contained learning of a + or - aspect of a features, then contrasting + and - of a feature and lastly contrasting + and - aspect in varying contexts.

The programme was complete when 90% accuracy was achieved. Feature generalization across the phoneme was found. The method was described as highly economical and elegant because the goal was to rectify the system rather than individual sounds. A feature may be a component of several sounds, if the feature is established in the context of one sound, all other sounds, bearing that feature are automatically corrected.

Feature generalization across phonemes during the articulation training was found by Griffiths and Craighead (1972) also Singh and Frank (1972) tested 90 children for consonant articulation problems using distinctive feature analysis and concluded

a) that the most recently acquired phonemes are replaced most often.

b) Phonemes used as substitutes are more often the ones learned earliest

c) Stop feature is the most frequent replacement for other manner features.

d) A place feature is substituted by feature which is the closest and more frontal in place and same in the manner of production.

e) Stability and interphonemic similarity are the main principles governing substitutions.

Oiler (1973) investigated application of generative phonology to speech sound substitution of 5 children. The results indicated that the use of distinctive feature system can help in searching for retularity and systematicity in seemingly irregular phonological system. Oiler and Kelly (1974) observed that the hard of hearing child's substitutions were similar to that of younger normal children.

Leonard (1973) described two patterns of articulation deviation. 1) Phonological immaturity, 2) Deviant articulation, where in the children do not follow the normal process. He further stated that the first group may grow out of the problem with time but the second group needs immediate clinical intervention.

Kelly et al (1973) stated that the classical articulation tests (Templin Darley Test) are the unitary measure of the patients articulatory performance, where as the distinctive feature test is a measure of differential skill on a number of parameters reflecting the patients' underlying competence. The later, thus gives the precise and efficient description of the problem.

Kamara, Kamara and Singh (1974) analysed substitution errors of 77 children with Kamara-Kamara and Singh articulation test of distinctive feature competence, and obtained feature gram profiles. Further they grouped the subjects depending on feature gram profiles as follows:-

Groups	Characteristics Feature-gram
1) Pathology, lesion organic	steady loss at all 7 features (less than 50%)
2) Retarded	Dip at voicing
3) Cleft palate	More than 70% for all features except front/back place and sonorancy.
4) Functional	Poor scores for place, better for sonorancy and nasality.
5) Specific learning disability	Significant dip at the features front/back place and labiality.

Costello (1975) described a procedure of application of distinctive feature in diagnosis and therapy.

a) Pre treatment measurement of articulation.

1. administer general articulation test to isolate phoneme errors.
2. deep testing.
3. Distinctive feature analysis.
4. select appropriate feature for training and select appropriate sound as a vehicle for instruction of these features.

b) Instructions:

1. Teach 3-4 phonemes together
2. Teach correct phoneme in connected speech.

c) Post treatment measurement of articulation:-

a. assess the progress with the test given before.

Mc Callum (1975) studied 50 children with articulation problem using Mc Reynold and Huston's (1971) technique of distinctive feature analysis. She did subjective analysis and found various patterns as related to each etiology. She concluded that distinctive feature patterning along with other data can prove to be a useful tool in differential diagnosis.

Castello and Onstine (1976) evaluated the effectiveness of remediation procedures based on distinctive feature theory through the administration of an articulation programme and concluded that distinctive feature training could produce cross.phoneme generalization.

Ferris (1978) analysed articulation errors using distinctive feature system for 14 children, and found that all children had difficulty with strident and high features. There was a difference between young and old subjects indicating that defective speakers progress throug the same stages as normals but at a slower rate.

Kim (1978) gave analysis procedure for deviant articulation using features. He suggested following steps.

1) Administration of deep articulation test.

2) Segmental feature, analysis:

(a) analysis of test phonemes

(b) finding out sum of total number of phonemes tested.

(c) Finding out frequency of correct responses.

(d) Analysis of incorrect responses.

(d) Counting frequency of incorrect responses

(f) Finding out number of cofrect usage.

(g) Finding out the sum of difference between correct and incorrect responses.

Kim (1978) concluded that the feature analysis is a tool for articulation testing but he contraindicated complete feature analysis when few errors are made.

Weiner and Bernthal (1978) proposed a test of articulation based on distinctive features. This test has two levels (1) To screen children's speech for pattern of feature errors (2) In second level a particular feature is selected and all the sounds in that language consisting of test feature are presented to note the frequency of correc or in correct usage of particular feature.

Based on their clinical experience they suggested several criteria for selection of a feature for training. These criteria are: (1) Redundancy (2) Number of feature error (3) Ease of articulation (4) Acoustic contrast (5) More visibility (6) Higher frequency of usuage (7) Physiolotical readiness.

Blache (1980) gave a linguistic approach to distinctive feature training. This method contains four steps.

1. The child must understand that the two contrasting words (minimal pair) differ in their meaning.
2. The child should discriminate the two words.
3. The child should produce the minimal pairs which are taught in response to picture stimuli.
4. Generalization.

Metz et al (1980) found a lack of generalization from one phoneme to other in hearing impaired adults.

Distinctive features have been utilized to analyze phonological behaviour of apraxic and developmental Dyspraxic individuals.

The distinctive feature analysis of defective articulati showed 2-3 feature errors. One place error and omission were found to be significant characteristics of Dyspraxia (Yoss and Darley; 1974).

Klich, et al (&980) analysed 825 consonants using distinctive features. The subjects were 9 apraxics. The result indicated that substitution patterns were systematic. More substitution errors were made in initial word position and on stops sounds. The retention and use of the features in the substitutions were closely related to the phonological markedness of the features. The marked was substituted by unmarked.

These findings supported the contention that errors are due to phonological deviation which are manifested in peripheral articulation changes. The consonant production is made simpler and the patterns resemble acquisition of articulation in childrens which supported Jakobson's hypothesis.

Investigations have explored phonological behaviour of aphasics with distinctive feature analysis.

Martin and Regrosky (1974) described the phonemic substitution errors made by a group of 15 aphasics in semantic and nonsemantic stimuli using distinctive feature system. The findings showed that the errors were not random and were highly similar to correct patterns.

Keller (1978) investigated vowel subsitutions in 5 Broca's aphasic's using distinctive feature system and markedness analysis. The tendency to use low vowels for high vowels was observed. This may be attributed to more simplicity in low vowel production.

Literature reports an additional application of distinctive features in the concept of 'markedness'. The theory of 'markedness' had 8ts origin in the early Prague school of Linguistics. This theory says, that all features composition a phoneme may be assigned a 'marked' or 'unmarked' value. The marking system indicates a relative complexity attributable to articulatory, and perceptual factors. When a feature is 'marked' in a phoneme, it indicates that in that phoneme that feature may require more articulatory or perceptual effort than in a phone in which it is 'unmarked', whether a feature assumes a 'marked' or 'unmarked' value depends upon the other features present in a phoneme. The complexity of phonemes is equal to the sum of its marked features.

Cairns and Charles (1969) prepared a table for 'markedne in which marked and unmarked value of features in the context of different phonemes are presented.

Children with misarticulation showed a typical pattern of substitution of features from more marked to less marked. The direction of change from more difficult to easy features could be explained using 'markedness' theory (Cairns and Williams, 1972).

Weiner and Bernthal (1976) did not find support fort 'markedness' theory in their investigation of normal feature acquisition in children.

Marquardt, Reinhart and Peterson (1979) did 'markedness' analysis of phonemic substitution errors in apraxic speech. The results showed higher error rate in phonemes with high 'markedness'. The directional changes in substitution were from 'marked' to unmarked'. These findings indicated that an 'apraxic' tries to reduce the complexity of articulatory gestures for phoneme production. Thus the D.F. system is useful in describing the articulation in normals and abnormals. The D.F. system is not only useful in analyzing the production of speech but also in the exception of speech.

The role of distinctive feature in perception of phonemes has been considered as vital (Singh, 1976). It has been found that in perceiving speech sounds, the listener is invoked by the distinctive features. The features are the underlying attributes of perceptual processing and thus speech sound perception and speech sound discrimination can be measured and quantified based on distinctive features. The application of distinctive features increases the efficiency and precision of evaluating speech sound perception.

1) Speech sound perception in normal hearing individuals:

Miller and Nicely's (1955) study showed that nasality and voicing show greater strength, ie. greater information transmission that the features duration, frication and place of articulation. The different features did not hold similar ranks in speech perception. The rank order was as follows: Nasality 62%, voicing 59%, Duration 41%, Frication 40%, and place of articulation 27%.

Singh and Black (1966) did a cross language experiment - where, listeners of Hindi,English, Arabic and Japaneese spoke and identified the identical set of 26 consonants in contexts of 2 vowels. Purpose was to establish a common set of parameters or features across the four languages and to investigate the Universal application of a selected group of consonantal features in speech perception. Rank order obtained was (1) Nasality (2) place (3) liquid (4) voicing (5) Duration (6) Frication (7) Aspiration.

Klatt (1968) did a study on the structure of confusions in short term memory between English consonants. There seems to be a natural.

Singh (1968) studied the errors in multiple choice intelligibility test, and Black (1957) studied the misarticu-lations by distinctive feature system. The results showed linear co-relation between the number of errors and distinc-tive feature differences.

Ahmed and Agarwal (1969) investigated the information transmission in 29 consonants in Hindi at the initial position and final position, in CVC syllable. They found that the features nasality and aspiration had most pronounced difference between their ranks both in initial and final positions.

Gupta, Agarwal and Ahmed (1969) determined the effect of clipping en the intelligibility of the consonant and features and to find out the amount of information given by initial consonants and final consonants and to note differences in consonant perception for these two position. Analysis revealed that the rank order of features in initial position was from most to least susceptable to clipping was place, nasality, liquids, and continuency. In the final position of the syllable the greatest amount of clipping effect was seen for the feature frication and nasality nd smallest for affricates.

Kennedy and Shankeveiler (1969) did a study on the hemisphere localization for speech perception. CVC syllables were given in dichotic pairs. Results revealed that significant right ear advantage was obtained for initial and final stop consonante and for the features of voicing, and place of production in stop consonants. They concluded that specialization of dominent hemisphere in speech perception is due to its possession of a linguistic device and not due to specialized capacities for auditory analysis.

Singh (1971) from a study concluded that (1) The distinguishing characteristics of voicing feature improved in noise and deteriorated in quiet.

2) Frication improved in quiet and deteriorated in noise.
3) Even in competition with other features, in quiet condition, voicing feature was stable.
4) Noise charactersitics of a friction were easily lost in the experimental noise.

5. Nasals, liquids, glides were minimally affected by filtering and noise.

Wang and Bilger (1973) found that nasality, voicing and roundness were perceptually important whenever they occured. Nasality was the best, perceived feature in this study.

Tannahill and Mc Reynolds (1972) investigated same or different discrimination task in 30 normal hearing subjects. By passing the stimuli via low pass filter, the discrimination task was made more difficult. The 45 consonant were embedded in CV syllables and they differed by 0, 1, 2 features. The features used were voicing, nasality affriction, duration, and place of articulation. They concluded that greater confusion occured when contrast was 0 or 1 featur and discrimination of consonant pairs was differentially affected by the number of opposing features contained in each pair. Thus features provide acoustic cues to discriminate speech sounds.

Singh and Blackman (1974) analyzed errors using distinctive features analysis, on modified Rhyme test, for 25 normal college students. The results indicated perfect correlation between number of feature differences and percentage of errors made. The percentage of errors decreased with the increase in the number of feature difference.

Binnie, Montgomery and Jackson (1974) studied perceptual confusions of 16 English consonants presented to normally hearing subjects under auditory visual and combined conditions in varying signal to noise ratio condition. The information transmission analysis and percentage correct intelligibility was found out for an articulatory feature class system. The results indicated that in auditory condition the features nasality and voicing were least affected by noise and place of articulation was most affected In visual mode subjects categorized phonemes into discrete homophenous groups. In the combined mode, the visual channel reduced place errors in various signal to noise ratio Conditions.

Dahhauer et al (1978) studied short erm memory recall for 18 consonants with /a/ in varying SN ratio, and subjects were 3 normal listeners. The results were analyzed by individual scaling method and the analysis indicated that the errors were few in quiet condition and increased with signal to noise ratio conditions The results also showed that voicing and nasality features were resistant to noise but place feature was not.

2. <u>Relationship between speech sound perception and production</u>

Williams and Mc Reynolds (1975) investigated the effects of discrimination training on production of speech sounds in 4 subjects. They concluded that production training was effective in treating both production and discrimination, where as discrimination training changed only discrimination.

Kumadavalli (1973) studied the relationship between articulatory performance and discrimination in school going children. A test of discrimination in Kannada using discrimination in Kannada using distinctive features was developed. The test consisted of minimal pairs having one or two distinctive feature difference. The picture pointing responses were obtained. Using the same pictures articulation was tested. The discrimination and articulation of each item were then compared. The results indicated that production always preceded perception.

3. Dichotic Speech Sound Perception:-

The literature in speech perception indicates that perception of vowels and consonants depends on different cues. Vowels are perceived based on acoustic or auditory cues available. Consonants are perceived based on extraction of linguistic features or acoustic restructuring of auditory parameters into so called 'encoded' phonetic parameters. Thus different perceptual strategies are employed to decode vowels and consonants and are also localized in right and left hemispheres respectively.

Fusisaki and Kawashima (1969) found that vowel perception had same processing mechanism as consonants, when their acoustic characteristics are changed, e.g. reducing the duration.

Crystal and House (1969) found that the major difference between the vowels and consonants is their inherent intensities. They found minimal difference in ear preference when the intensities were equalized.

Studdert, Kennedy and Shankweiler (1970) investigated role of dominant hemisphere in the perception of both vowels and consonants. The results indicated significant right ear advantage for initial and final stops and nonsignificant ear advantage for vowels. The significant, ear advantage for articulatory features place and voicing proved that specialization of the dominant hemisphere in speech perception, and is due to its possession of a linguistic device. It is reported that both the hemispheres have capacity for auditory analysis. Ability of the dominant hemispehre to perceive consonants is considered as due to its ability to extract linguistic features.

Day and Vigorito (1972) dichotically presented syntheti syllables containing plosive, liquid, and vowel categories for temporal order judge-ments. Stop sounds had right ear advantage liquid showed no ear advantage and vowels had left ear advantage.

Cole and Scott (1972) found that the reaction time was greatest when pairs of syllables were most similar.

Blumstein and Cooper (1972) found that the discrimination task was better when the consonants differed by more than one feature. The feature differences in the identification task had to be scored in short term memory as well as be processed for discrimination. Thus indicating that a loaded system and resulted in poorer scores.

Blumstein, Tartter and Michael (1973) studied perceptual reality of manner features in dichotic listening. The manner features were presented in CV context. The results indicated clear cut riqht ear advantage for consonants. The findings showed that riqht ear advantage was more for fricative and stops than nasality. In 1977 they found that perception of vowels was not lateralized.

Hayden, Kirstein and Singh (1979) evaluated the role of distinctive features in 21 dichotically presented syllables. The ear advantage was the greatest for stops and varied as a function of manner class. The number of feature difference between the consonants also affected identification. There was dominance of un-marked specification over marked one. This may be due to the fact that the stress of the dichotic presentation situation leads to simplification of response.

In conclusion it may be stated that "Those speech sounds which are highly encoded are dependent on perceptual decoding by specialized left hemisphere processors" (Libermann et al 1987).

The review so far shows the role of distinctive feature in the perception of speech sounds attempts have been made to analyze languages to note the role of different D.F's in them.

Different methods of analysis of D.Fs have been used the acoustic method has been used by Jokobsen, Fant and Halle (1952). They proposed 12 binary, Universal features using acoustic terms based on the 'Spectrographic' analysis. They demonstrated clear acoustic distinction between consonants and vowels. They believed that in no language all these features are used. Based on 'Received pronunciation' of English they specified 7 features to describe the English language.

Investigators at Hakins' laboratory have tried to find distinctive characteristics with the use of speech synthesizers. They have found that the voice onset time, in harmonic noise duration,Forman frequencies and formant transitions are some of the acoustic cues which help to discriminate the speech sounds (Liberman et al 1952).

Massaro and Oden (1980) studied identification of synthetic stop consonants as either /bret/, /pret/, /dret/ and /tret/ in two experiments in which the stimuli varied independently on voice onset time (VOT) and formant transition (F_2, F_3). In experiment two, the intensity of the aspirated noise during the VOT was varied. The result indicated that there is interaction in the evaluation of acoustic features and the listeners need more extreme values of acoustic features for some speech sounds than for that of other sounds.

Soli (1979) investigated the utility of phonetic feature versus acoustic properties for describing perceptual relations among speech sounds. The statistical analysis was done by INDSCAL program. The results indicated that acoustic properties of speech may give a better account of observed perceptual relation among speech sounds. These acoustic properties are:

1) Temporal relation between periodicity and burst onset.

2) Shape of voiced first formant transition.

3) Shape of voiced 2nd formant transition.

4) Amount of spectral dispersion. Thus he stressed on acoustic properties of speech signal for distinctions.

The spectrographic techniques introduced by Bell Telephone Laboratory are still most important means of knowing the characteristics of speech waves.

Vowels and voiced sounds possess periodic or rather quasi periodic wave forms and accordingly displav harmonic spectra. The fine structure areas as a result of opening and closing movements of the vocal cords periodically modulating at the rate of F , which is the fundamental frequency. In narrow band spectrograms F_0 is the harmonic spacing and in broad band spectrograms F_0 is the time interval between successive striations each reflecting a single voice cycle. The air cavities within the vocal tract act as a multi-resonant filter on the transmitted sound and impress upon it a corresponding formant structure super-imposed on the harmonic fine structure. These can be seen as F_1, F_2 and F_3; which are main determinents of the phonetic quality of a vowel. They are conceptually contained in the term 'F-pattem', more or less continuously across the often sharply time localized breaks in the spectrogranhic time-frequency-intensity picture. Each position of the articulatory organs has a specific 'F-pattern'. The time variation of the 'F-patter' across one or several adjecent speech setments are referred as "F-formant transitions", which are important cues for the identification of consonants.

Continuous elements of speech are due to the continuity of the position of the articulators; descrete breaks being mainly due to shift, manner of production, that is a change in active resonator system, etc. Spectrograms might convey an overflow of data. Binary coded pattern aspects as well as quantized parameters data belong to the inventory of such specification.

When processing the spectrographic data in connected speech the first object is to identify the boundaries of successive sound segments. A phoneme may be physically encoded.into smaller or greater extent in the pattern aspect of several adjacent sound segments. For Eg: Stop sounds are considered as made up of the occulusion, burst, the explosion transcient, a short fricative and a /h/ sound. Identification of a features are based on the following parameters. (1) Duration, (2) Intensity (3) Energy (4) Voice fundamental frequency (F_0) (5) The 'F pattern (F_1, F_2, F_3 etc) (6) Formant structure (frequency intensity distribution, spectra) (7) Fine structure - referinq to speech production, the source.

Articulatory Method:-

This method was used by Chomsky and Halle (1968). A universal set of phonological features was developed based on the phonological theory of generative grammer.

They described the articulatory features of universal sounds. The features are binary and are defined by antonymus adjectives. The vocal mechanism was considered in terms of source, areas of vocal tract involved, position of the tongue in relation to different areas and also oral and nasal cavity differences in terms of volume. Eg. coronal/non-coronal - Coronal feature present in sounds which are produced by the blade of the tongue raised from neutral position. Chomsky and Halle (1968) believed that the features extracted by this articulatory method provide a representation of utterance which can be interpreted as a set of instructions to the physical articulatory system.

Recently Weiner and Bernthal (1976) proposed a set of phonetic features. The features are related to articulatory characteristics of speech sound production. The features were intended (1) to represent the essential articulatory characteristics of all speech sounds (2) To provide means for aberrant speech production.

Perceptual method:-

This method deals with the question of perception of speech sounds in the frame work of a theory of speech perception. It is believed that distinctive features are the bases of decoding auditory stimuli. The distinctive features play a great role in perception of speech stimuli. In this method the features are retrieved from various statistical analysis.

Perceptual method has been used by Miller and Nicely (1955), Singh and Black (1969), Singh (1968), Wickelgren (1966) for consonants and by Shepard (1972); Singh and Woods (1971), Terbeek and Harshman (1971).

Singh (1975) describes these perceptual methods as

1) Designation of ,apri ri features to predict perceptual responses.
2) Extraction of aposteriori features from these responses.

In Apriory designation of a feature system to predict perceptual response: method the experimenter determines how and based on how many dimensions the date will be analysed prior to analysis. Thus a feature system is proposed and then the experimenter evaluates the strength of the proposed feature system based on perceptual responses. The strength of a feature system as a whole and also the relative importance of each feature in given feature system is determined; based on perceptual responses.

The importence of distinctive features in a language is determined by presenting the distinctive feature in question in any of the following conditions.

i) conditions of acoustic distortion noise and filtering of the stimuli (Miller and Nicely 1955).

ii) Cross linguistic settings (Singh and Block, 1966).
iii) Recall in short term memory (STM) (Wickelgren, 1966).
iv) The utilization of choice reaction time as a measure of distinctive feature differences between the phonemes (Cole and Scott, 1972, Weiner and Singh , 1974).
v) The judgement of pairs and traisl of speech stimuli utilizing various psychological methods for exiciting perceptual responses (Singh, 1970b; Singh. 1971

Singh and Becker, 1972; Wang and Bilger, 1973).

Singh (1976) stated that "while all of the above studies prove unambiguously that all features of a given system are not of equal importance, they do not agree regarding the explanatory powers of a given feature system". Limitation of the above system are:

1. It leaves to choose the features arbitrarily
2. It lacks flexibility
3. It does not have the provision of adding a new feature and eliminating a known one.

2. In Extraction of apsoteriori features from perceptual responses method one can over come the disadvantages of apriori system. Here the features are retrieved with the help of various statistical measures from the perceptual data collected. The features are selected from the data and then the feature system is established.

The various methods of collecting perceptual data are (1) Similarity judgement by triadic comparison (2) confusion matrixes (3) Magnitude estimation by 7 point scaling (4) choice reaction time. (5) Same or different judgement.

The data collected by these various perceptual method can be subjected to different statistical analysis methods. They are: (1) Factor Analysis (2) Contingency tables (3) Multi dimentional scaling Analysis (4) Individual scaling analysis.

Computer Analysis: - As the distinctive feature analysis is too laborious and time consuming, the latest trend is to study the distinctive features in misarticulation cases with the help of computer technology (Albert et al, 1981) In order to provide a rapid, accurate and efficient method, the computer analysis has been developed.

Telage (1980) did a study on the computerized place-manner distinctive feature programme for articulation analysis where in the primary objective was to point out the patients articulatory behaviour that contributes maximum to misarticulation. Primary utility of the computerized analysis was to generate specific detailed information of developing individualized strategies for therapy.

Elbert, Laman and Bruce (1981) analyzed misarticulations using computer technology. The wanted to develop programme wherein the clinician could enter the data directly from a vedio terminal to a computer. The computer programme followed the steps of feature analysis given by Mc Reynolds and Engmann (1973) based on a feature system of Chomsky and Halle (1968). The programme written in Fortran was developed on Control Data Corporation 6600/ Cyker 172 computer. It required 50,000 words and when data entry was completed, the programme calculated.

l) The number of times each feature was used correctly for the phoneme tested. ,

2) The plus and minus aspects of each of the 13 features.
3) The percentage of times that the plus and minus aspects of a features used incorrectly.

The review of various methods of extracting features from a language reveal that articulatory, acoustic and perceptual methods can be used independently. It can be postulated that combination of more than one method may be useful in obtaining substantial results and it may also reveal the correlation of the results of one method to that of others.

The concept of distinctive features has been found to be useful in studying (1) articulatory behaviour (2) Speech sound perception and (3) Phonological acquisition.

One of the most of ten quoted advantage of the distinctive feature system is, its economy and efficiency.

The method of teaching articulation Using D.Features is time saving, because many misarticulated sounds can be corrected by correcting one or two features.

This process of teaching the feature and $ts generalization has greater validity since by introducing the feature, the correction becomes more control and stable, then mearly correcting a mis-articulated sound.

A feature-gram is preferred to the traditional speech discrimination or articulation tests (Danhauer and Singh, 1975). Processing of phonemes of hard of hearing can not be predicted by pure-tone audiogram, which deals with specific frequencies. The speech discrimination does not present an interaction of the ear and the crucial properties of speech sounds. Phoneme perception is a function of distinct articulatory features of consonants and vowels. Plotting patients speech discrimination or articulation scores in the form of features will more meaningful. By looking at the feature gram one can play therapy better. Thus the feature gram can be used for diagnostic, prognostic and therapeutic purposes.

The use of the binary principle in the distinctive feature system, enables the analysis to be done by a computer system. Further the nervous system has been found to analyze the information using binary system.

Martin and Rigrodsky (1974) state one of the advantages of the distinctive feature as that it serves both as a aid in phonological analysis".

Distinctive feature analysis can be applied to any clinical population for diagnosis and therapy.

Distinctive features are used in the production of Computer speech and in speech synthesizers.

However, some have considered that there are certain limitations in the use of these distinctive features.

The analysis of the distinctive features is a very laborious and time consuming one. In order to overcome this problem, computers can be used, but it is costly, and may not be available to all.

Postal (1968) writes that "the classificatory level of disti ctive features does not really think of the feature relavent for the discription of phonetic detail, i.e. not thinking of them as premitives of narrowest phonetic representation required to give pronounciation instructions".

La Riviere et al (1974) assessed the conceptual reality by a sorting task suggested by Winitz (1972). A series of sounds were presented several times in random order, and the subjects were asked to assign sounds to one of the two categories. The subjects in control group. classified the sounds only with the help of paired association, where as experimental group could classify the sounds both on the basis of distinctive features and paired association. The features used were voice, nasal, continuent, strident and vocalic. The results indicated that there was difference between experimental and control group. This difference was considered as due to the use of features nasal, Strident, and vocalic by experimental group, voice and continuent features were considered to be not useful in sorting and considered conceptually not real.

Ritterman and Freeman (1974) supported the above view and found no significant differences in performance as a function of number of the irrelevant dimensions nor characteristics or relevent dimensions. The results indicated that no perceptual dimension (Feature) was more important than the other.

Walsh (1974) criticises the feature systems which give importance to structure of phonological contrasts and ignore the concrete manifestations, and questioned the applicability of feature system put forth by the prague school of linguistics.

Leonard (1974) states that the distinctive features serve two functions - As abstract classificatory function and the phonetic function. At the abstract level, the features assume two values + and - , at the phonetic level they are physically represented and they may indicate ranging degree of + or - parameters. An instructor should use the phonetic level and just not binary specifications.

Parker (1976) compared existing distinctive feature systems and has drawn the attention to the fact that all the feature systems are not the same. They have different theoritlcal backgrounds. Some (Chomsky and Halle, 1968) have a strong theoritical support where as some (Jakobson, Fant and Halle, 1955) do not have it. Parker (1876) also pointed out the abstract representation of phonological feature system; and advocated to add a production matrix to consider physiolggical phenomena and to relate them to abstract entities.

Singh (1976) puts several limitations together for the distinctive features which do not consider co-articulation and timing factors in speech production. Moreover they may vary with dialects and prosody of the speaker.

Lund and Duchan (1978) states that distinctive feature approach does not detect within phoneme errors; and does not reveal consistency unrelated to features and also does not explain omission, where error-target matching is not possible. The authors advocated a multifaceted approach to overcome the limitations of the various individual approaches. This multifaceted approach included phonemic analysis, feature analysis context sensitive analysis, reduplication analysis, assimilation analysis and idiosyncractic analysis, and they found this approach to be useful.

Thus it can be concluded that some more intense research is needed in this field. But inspite of all these limitations, the distinctive feature concept is still considered as a valid and useful tool) in the studies in speech science and in the speech correction.

Speech pathology is a behavioral science which deals with the understanding, assessment, and treatment of speech and language disorders. This necessitates a good understanding of the patient, and in addition, the language to be taught. The situation in India, with its multiplicity of linguistic groups, presents itself, additional problems in that the speech clinician may have to work with language non-native to him. Recently there has been great emphasis on distinctive feature analysis of speech. Various language have been analyzed to obtain D.Fs underlying them. However there are very few studies on Indian languages.

Ahmed and Agarwal (1969) attempted to find the significant features of Hindi consonants. A quantitative procedure was adopted to ascertain the features that were most significant to the listeners and to note whether or no they are similar in initial and final positions. The amount of information transmitted in bits/stimulus was also calculated for a given feature. Results indicated that semivowels and afficates were most intelligible and that major iconfusions existed among plosives. In both positions, confusions occur most frequently between consonant classes distinguished by a single feature. In the initial position, confusions generally arise due to manner of articulation, and in final position confusions arise in terms of place of articulation. They also found that initi and final vowel transitions play a very important part in recognition of consonants.

Somasundaran (1972) has done a contrastive study on phonology of Kannada, Telugu, Tamil, and Malayalm languages based on distinctive features. Eleven (11) distinctive features were proposed and they Here:

(1) Vocalic (2) Consonantal (3) Nasal (4) Continuous
(5) Tense (6) Grave (7) Compact (8) Flat
(9) Diffuse (10) Sharpe (11) strident.

Based on the analysis it was found that Malayalam language has the maximum number of feature distinctions, and maximum number of phonemes, among the four languages studied, i.e. Malayalam, Kannada, Tamil and Telugu. Features one (1) to nine (9) were common to all languages where as 11th was significant in Tamil and Malayalam only and 10th was significant only in Malayalam.

Fulguni (1981) established a distinctive feature system for consonants in Gujarath. 65 minimal pairs were constructed using 32 consonants. Features proposed were voicing. Nasality,labial, Alveolar, Dental, Retroflex, Velar, Aspiration, Affrication, semivowel, Lateral, Flap and Frication. She has analyzed using both receptual and acoustical methods.

The conclusions made from the study were, (1) there is a distinctive feature system in Gujarati language (2) It can be proposed based on phonetic description (3) All distinctive features have a definite acoustic characteristics (4) All features do not carry equal importance for speech perception.

Valentine (1977) proposed a system for classifying phological systems into the following features; 1) Back/Non-Back (2) Nasal/Non-nasal (3) Obstruent/ Non-obstruent, (4) continuant/Non-continuant, (5)Retracted/ Non retracted (6) Retroflex/Non-retroflex? (7) Aspirate Non-aspirate, (8) Palatal/Non-palatal (9) Retracted/ Non-retracted non lateral non-obstruent, (10)Coronal/ Non-coronal (11) lateral/Non-lateral (12) Retracted/non-retracted nonconsonantal non obstruent (13) voiced/ voiceless. Ramaswamy (1980) studied phonetic features of Tamil sounds. The features necessary to distinguish vowels are tongue features (high, low and back).

Features necessary to differentiate the consonants are nonsonorant or obstruents. Stops and affricates are differentiated by feature continuent. Point of articulation is also neeessary. The feature anterior distinguishes sounds that are produced in which are produced at the back of the alvelo-palatal region.

Mallikarjuna (1974) found that the native speaker of Kannada who are not exposed to Sanskrit language are not able to make-out the differences between aspirated and unaspirated recognizing and reproducing the same. Spectrographic studies showed that aspirates and unaspirates and unaspirated + 'h' are different.

Arati (1983) attempted to establish D.F. system for Malayalam consonants, using both acoustic and articulatory methods. The following features were found to be present (1) Back/Non-back, (2) Nasal/Non-nasal, (3)Continuent/Non-continuent (4) Obstruent/Non obstruent (5) voiced/Non-voiced; (6) Retracted/Non-retracted, (7) Retroflex/Nonretroflex (8) Palatal/Non-palatal, (9X Aspirated/Non-aspirated (10) Coronal/Non-coronal, (11) consonantal/Non-consonantal. However no study of D.F. of Kannada consonants was available to the present investigator. Thus to make use of the D.F. system for the purpose of construction of articulation and perceptual tests in Kannada and for the purpose of therapy in Kannada, it was found necessary to analyze Kannada consonants for D.Fs. Therefore the present investigation was undertaken.

CHAPTER III

M E T H O D O L O G Y

The present study is carried out to explore the possible existence of distinctive feature system for consonants in Kannada and to establish acoustic distinctive charactersitics for this feature system.

The distinctive feature system proposed for describing the consonants in Kannada language consists of following featur s (1) Voicing (2) Nasality (3) Continuent (4)Anterior (5) Coronal (6) Stridency (7) Lateral (8) Aspiration. This set of distinctive features are based on distinctive feature system proposed by Chomsky and Halle (1968).

The consonants considered here are based on the phonetic classification in terms of manner and place of articulation of consonants in Kannada language (Hiremath, 1980).

This study has been restricted to 31 consonants only, eventhough Kannada has 34 consonants, and 8 allophones of these consonants. The sound /s/, /&/, /%/, were not included in the study because of their frequency of occurrence was very less in the language.

The following experiments were condicted in order to fin out the efficiency of the proposed feature system by (1) Acoustic analysis and (2) Perceptual analysis.

1. Acoustic Analysis:-

a) Stimuli:- 37 minimal pairs were chosen consisting of 31 consonants of Kannada language. These minimal word pairs permit comparison of features as words differed from each other at least by one features.

B) Equipment:- Speech spectrograph (VIII MK 700) which has provision for continuous recording and to analyze speech sample of 2.4 second duration at a time was used.

C) Procedure:- The 21 minimal word paris were recorded using the tape recorder of speech spectrograph on a profo-ssional. The speaker had tape Kannada as mother tongue and had no speech and hearing problem. The V.U. meter of the tape recorder was used to monitor the intensity. A gap of approximately, one second was given between words of a pair. This recording was done in the speech lab. of A.I.I.S.H.

The wide band spectrograms for each word pair were obtained using the speech spectrograph.

The spectrograms thus obtained were analysed to note the following characteristics, (i) Voice lag or voice lead (ii) Formant transition (iii) Frequency at which concen-tration of energy is seen (iv) Presence of periodic or aperiodic energy.

This analysis was done to find the acoustic correlates of features proposed.

2. <u>Perceptual Analysis</u>:- This experiment was divied into part I, and part II.

<u>PART I:</u>

a) <u>Stimuli</u> Consisted of 916 words derived from 458 minimal pairs The minimal pairs were recorded in a random order. The words were recorded using COSMIC recording deck and pPhilip's microphone.

b) <u>Subjects:</u>- The subjects were 15 males and 15 females. They were college students having Kannada as their mother tongeu. They ranged in age from 18 to 23 years. They had no history of speech and hearing problem and they could read and write Kannada.

c) <u>Procedure:</u>- The tape recorded words were played through ear phones, to each listener in a quiet room. The following instructions were given in Kanndda language.

" ಈಗ, ನೀವು ಕೆಲವು ಕನ್ನಡ 'ಪದ ಜೋಡಿ'ಗಳನ್ನು ಕೇಳಲಿದ್ದೀರಿ. ದಯವಿಟ್ಟು, ಗಮನವಿಟ್ಟು ಕೇಳಿ. ಪ್ರತಿಯೊಂದು ಪದ ಜೋಡಿಯನ್ನು ಕೇಳಿದ ತಕ್ಷಣ, ಅದನ್ನು ನೀವು ಕೇಳಿಸಿಕೊಂಡ ರೀತಿಯಲ್ಲೇ, ತಿರುಗಿ ಹೇಳಿ."

(Now, you are going here several Kannada words pairs Please listen to them carefully. As soon as you hear the word pair, repeat that word pair loudly as you have heard).

These response of the listeners were recorded using a tape recorder for scoring and analysis using National

Panosonic tape recorder.

The same procedure was followed for all the 30 subjects.

d) Scoring:- The responses of all the subjects were scored as 'correct' or 'incorrect' by the experimenter A response was considered as correct, if the spoken response was same as the stimulus presented. A response was considered incorrect when the spoken response was different from the stimulus word presented. i.e. when a sound in the stimulus word presented was substituted or omitted, or distorted.

The incorrect responses were further analyzed to find out the sounds which here substituted and the sounds for which substitutions were made.

PART II

a) Stimuli - As in part I

b) Subjects:- 15 males and 15 males who were not having kannada as their mother tongue and/or native language were chosen as subjects. These college students ranged in age from 18 to 23 years. They had no history of speech and hearing problems.

c) Procedure:- As in part I, but instruction was given in English.

The same procedure was followed for all 30 subjects.

d) Scoring: The spoken responses of all the 30 subjects were scored as in part I.

CHAPTER - IV

RESULTS AND DISCUSSION

The results of the two experiments conducted provide the acoustic correlate for the distinctive feature system proposed for the consonants in Kannada and also the amount of information carried by each distinctive feature.

As stated earlier the proposed distinctive feature system for consonants in Kannada consists of 8 features
1) Voicing (2) Nasality (3) Aspiration (4) Anterior
5) Coronal (6) Stridency (7) Continuent (8) Lateral.

I. Acoustic Analysis:-

Wide band spectrograms for 37 word pairs were studied. The close inspection of all the spectrograms revealed distinct acoustic characteristics for each feature proposed.

The distinctive acoustic characteristics for the proposed distLncrive features are as follows.

1) Voicing:- This feature is studied in great detail by earlier investigatos (Fry, 1979; Pottet Kopp and Kopp, 1966; Jakobson, Fant and Holle, 1952).

The essential acoustic charactersitics for voicing distinctions which can be seen in a spectrogram are:

1. Presence of low frequency energy termed as "Buzz" (Jakobson, Fant and Halle, (1952) in voiced sound and absence of this in voice-less sound. The presence of this charactersitic is marked by voice bars along the base of the spectrogram which are identifiable as vertical striations occuring at regular interval.

2. Voice onset time is identififed as voice lead in voiced sounds and voice lag in voiceless sounds.

3. The energy concentration in the noise components of the spectrum either in stop or fricative sound is greater in voiceless than in voiced sounds.

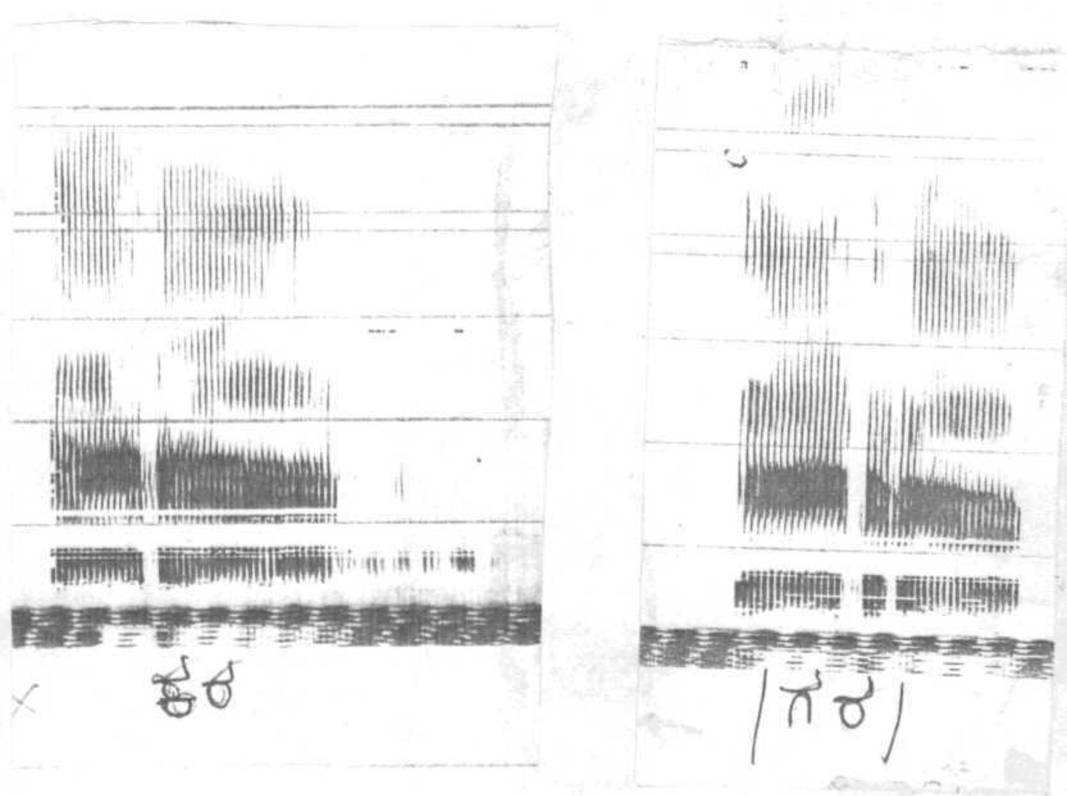
Therefore it can be concluded that presence of voicing feature is acoustically represented by the presence of

1. Regular vertical striations in low frequency region which occur simultaneously with the burst (stop or frication) indicating voice lead.
2. Decreased intensity of burst when compared to its voice less counterpart.

These characteristics have been observed An the consonants of all languages. The acoustic characteristics are shown in the spectrogram given below.

Eg:-

Eg:



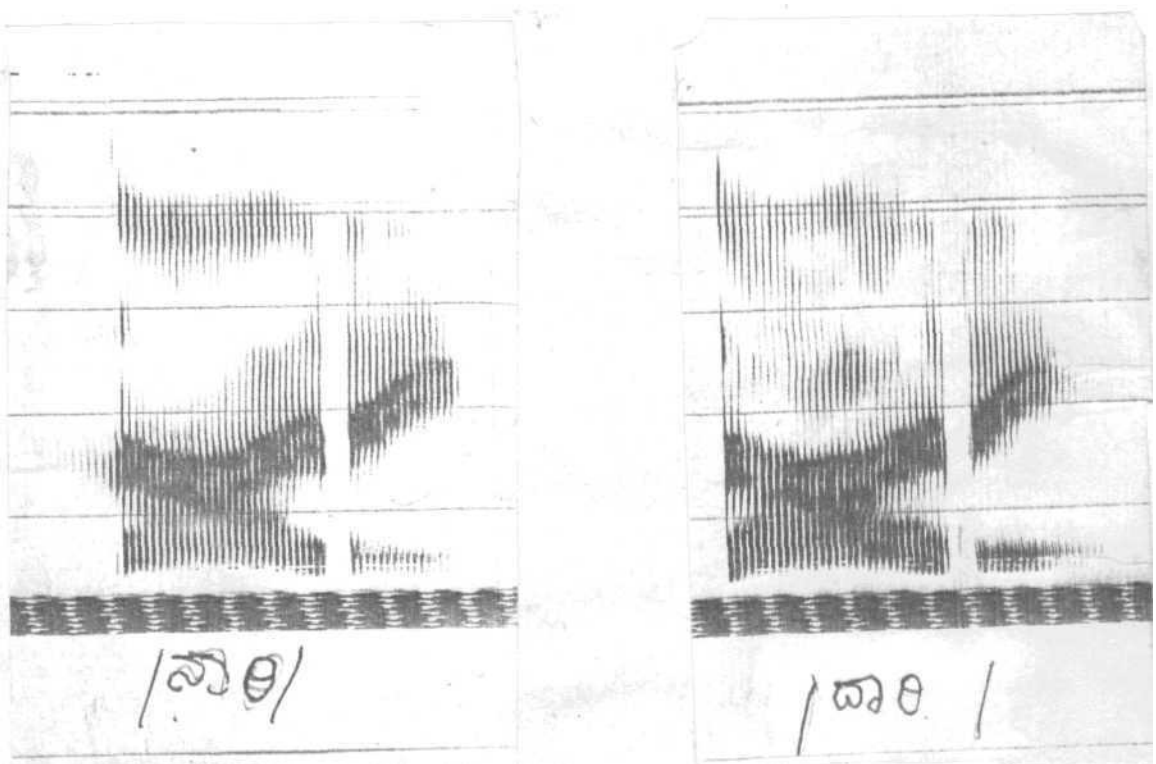
2. Nasality:- Acoustic characteristics of nasal feature are described as having a characteristic nasal formant at low frequency (200 Hz) and at very high frequency (2500Hz), and a tail like appearance. It has also been reported that there is very little high frequency (Danial OFF et al, 1980; Jakobson, Fant and Halle, 1969; Fry 1979; Potter et al 1966).

It was observed that low frequency formant and tail like appearance were present for all nasal consonants studied. The high frequency formant was not observable. This may be due to reduced energy concentration at hirh frequencies.in nasal sounds.

Therefore it can be stated that nasality feature is present in Kannada language and it can be identified by

1. Presence of low frequency formant,
2. Tail like appearance.

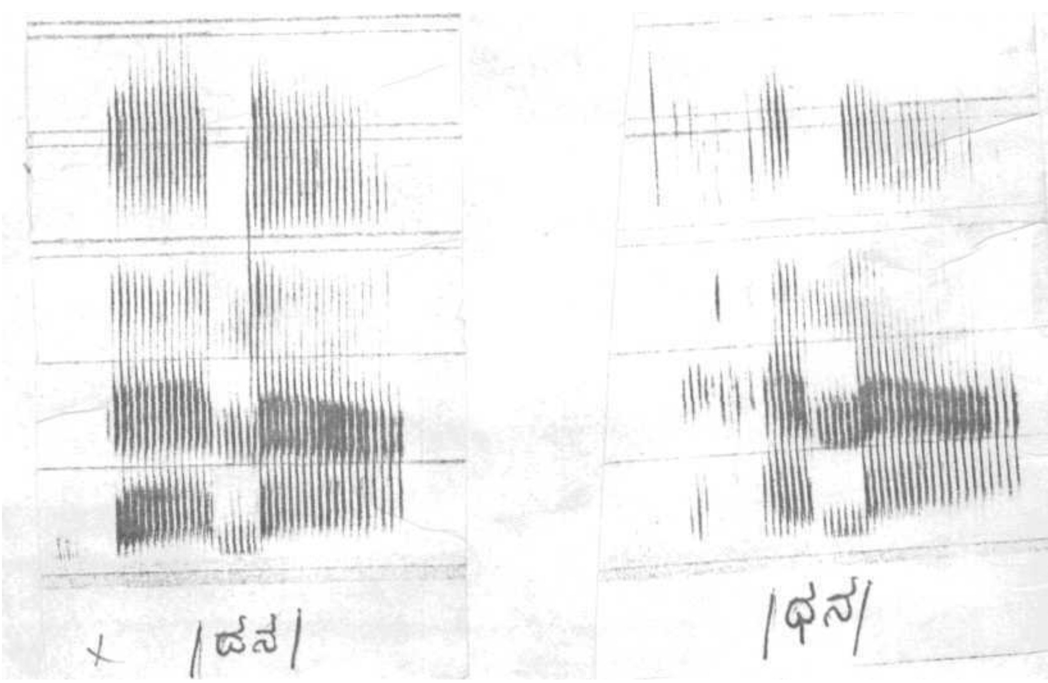
These acoustic characteristics are shown in the spectrogram given below:



3. Aspiration:- The feature aspiration is not an important distinctive feature in spoken Kannada, eventhough it is present in the Kannda phonemic system. Mallikarjuna (1974) found that the native speakers of Kannada who are not exposed to Sanskrit language are not able to make out the differences between aspirated sounds and unaspirated sounds.

The acoustic cue for this feature is extra-energy concentration in aperiodic portion i.e., at high frequencies mimicing the friction noise in stops, frecatives, and affricates.

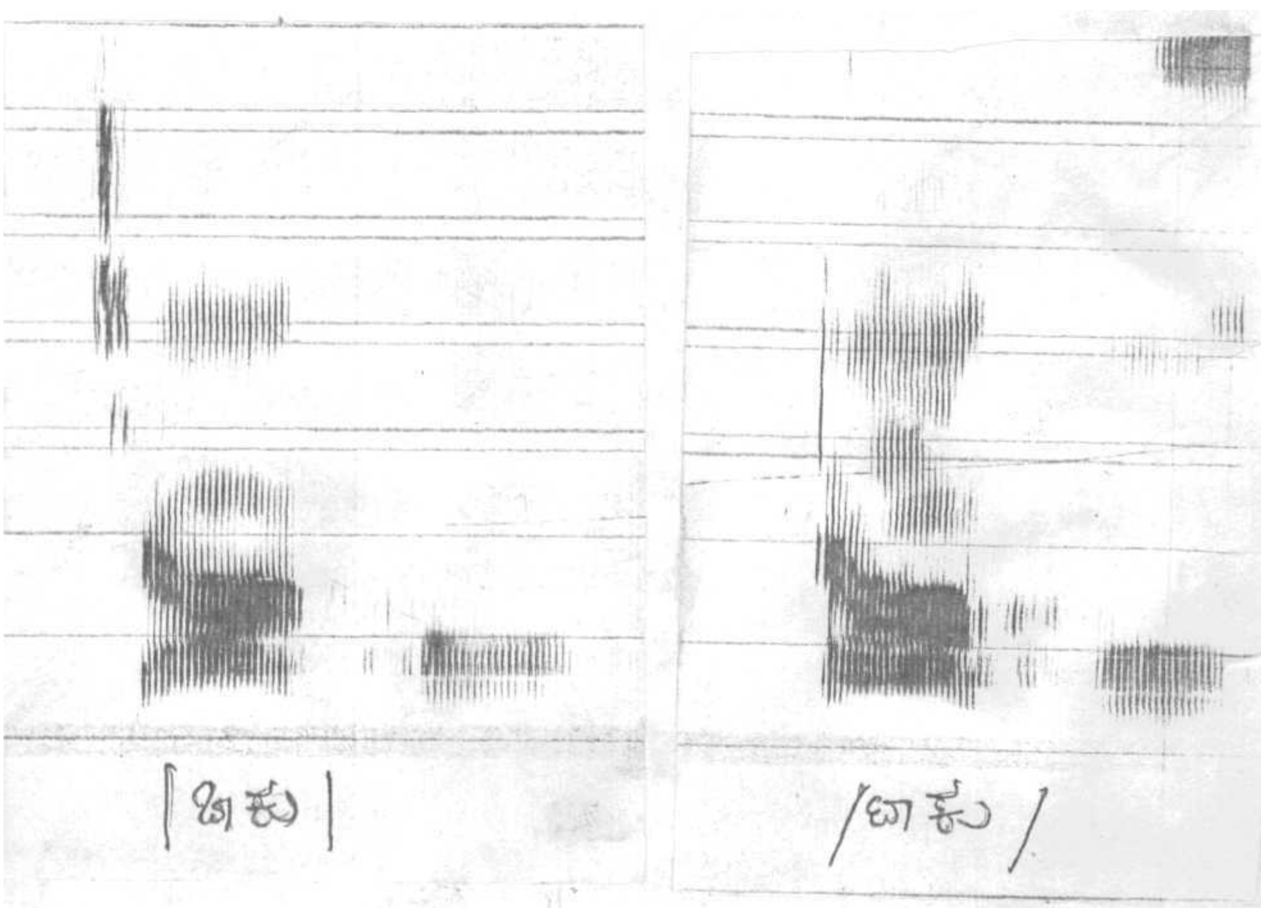
Therefore it can be stated that the presence of the feature aspiration, is marked by extra-energy concentration in aperiodic portion of the consonants at high frequencies which is identifiable on spectrogram as dark patches in the upper portion. A representative spectrogram is given below.



4. Stridency:- This feature has a irregular wave forms. In the spectrogram such sounds are represented by a random distribution of black markings.

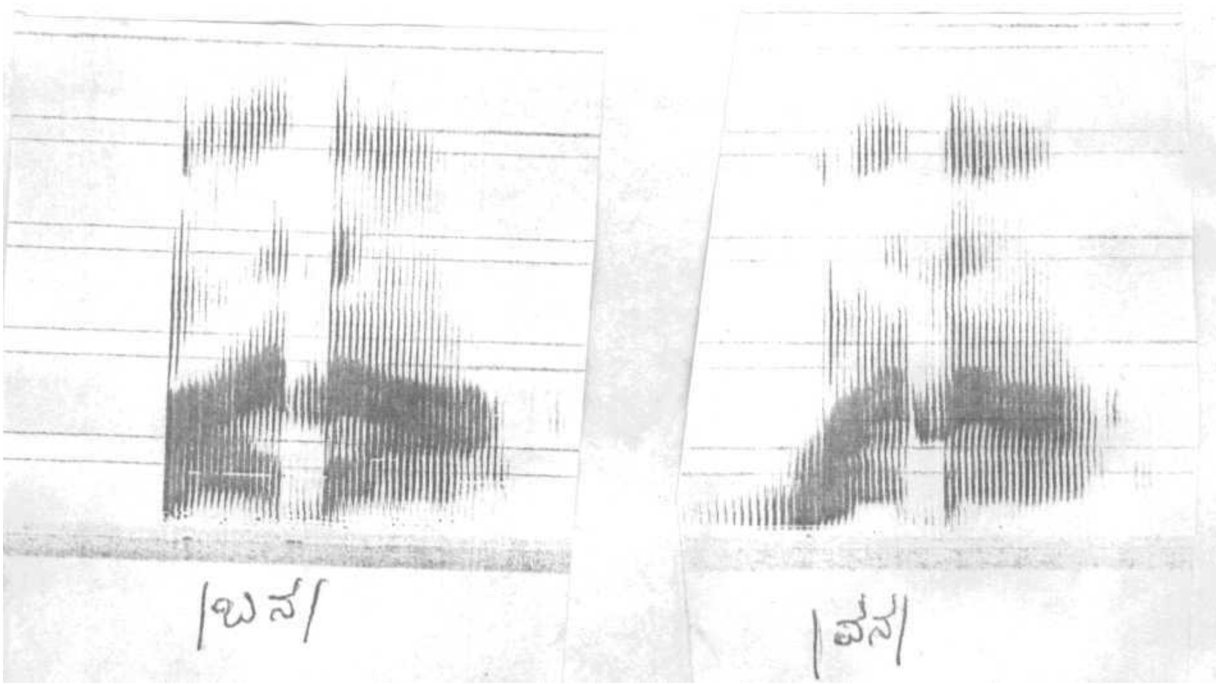
The acoustic cue for this feature is high frequency turbulence of (Longer duration and greater intensity.

Therefore it can be concluded that the presence of the feature aspiration, is marked by a dark, aperiodic portion of a longer-duration at high frequencies. A representative spectrogram is given below:



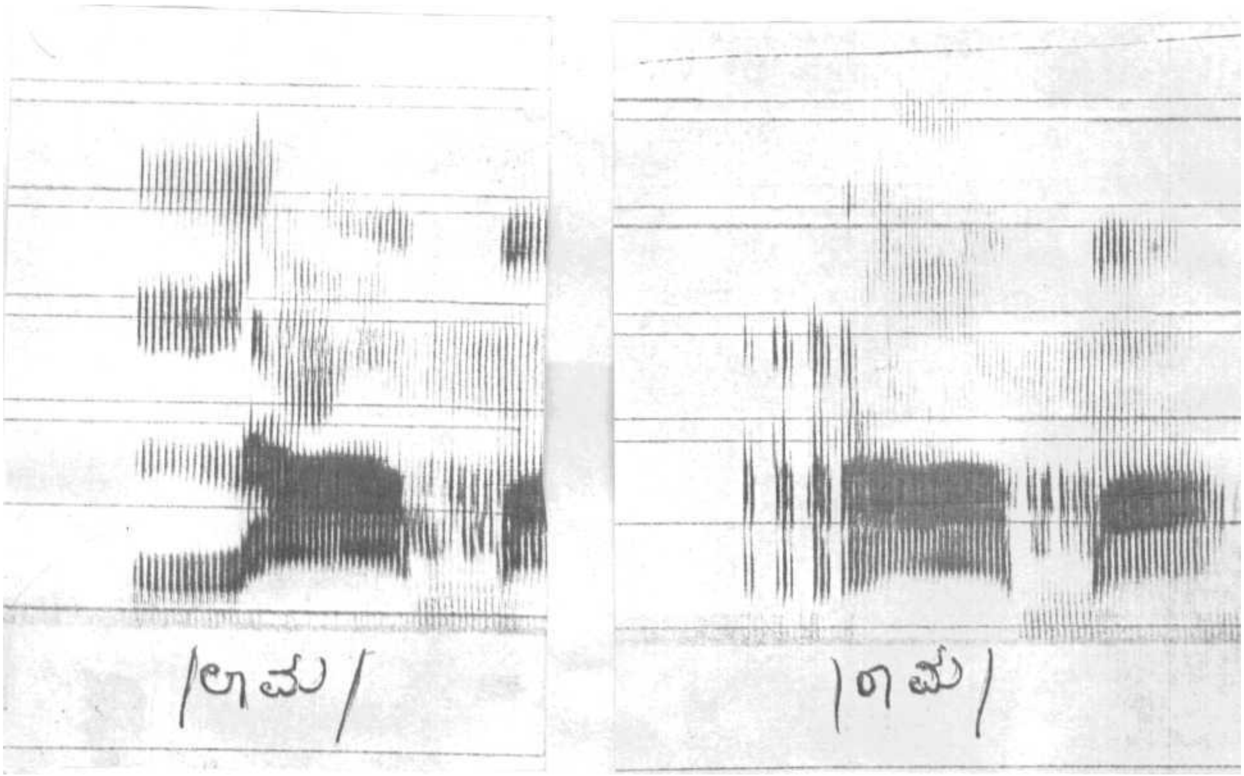
<u>Continuent</u>:- The acoustic characteristics seen in this feature are: a gradual on set of vibration, which is continued for a considerable length of time as can be seen in the production consonants like, /s/, /r/, /1/. Whereas the non continuents present a sudden burst of vibration <6or a very short duration as can be seen in /p/, /b/, /t/, /d/. Thus the acoustic characteristics seen are (1) gradual onset (increase in intensity with time) (2) longer duration of vibration.

A representative spectrogram is given below:



Lateral: - Jakobson, Fant and Halle (1952) state that lateral sounds are associated with vowel like and consonant like characteristics. The continuous bars in them are representative of vowels and the gaps are characteristic of consonant parts.

Examination of words containing lateral sounds show the presence of the small gaps as shown in spectrogram. Eg:- /1/ and /l/.



Anterior:- It is not possible to differentiate 'Anterior' and 'nonanterior' as these sounds vary interms of duration of VOT and transition of forments. As the constriction of vocal tract moves backwards, the duration of VOT increases

ChomsRy and Halle (1968) defines that all labial, labio-dental, dental and alveolar sounds as anterior and palatel, retroflex, velar, and glotal sounds us non-anterior. Based on this places of articulation it is possible to give acoustic charactersitics.

Labial:- Downward transition, low frequency peak and very less VOT.

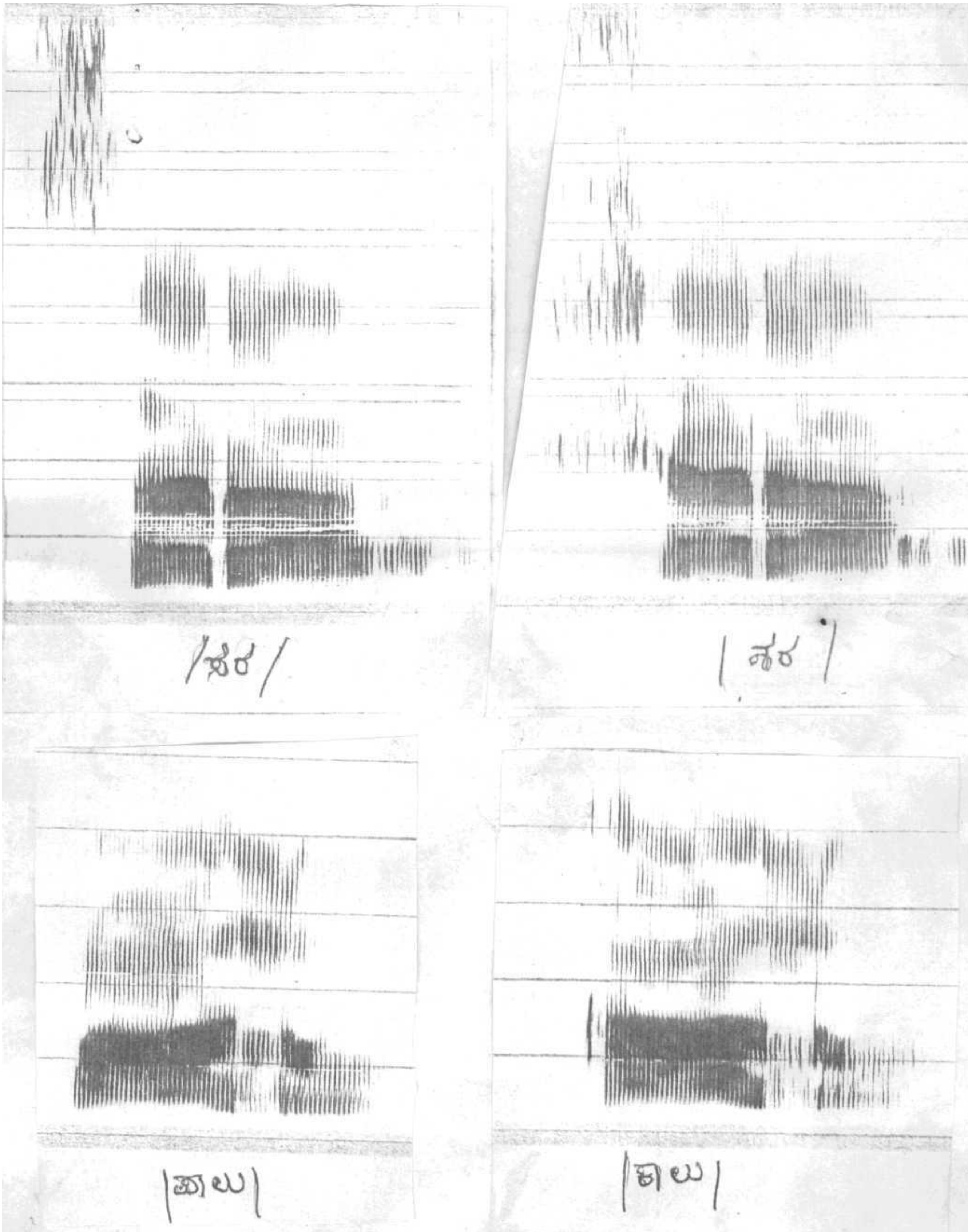
Dental:- Upward shift, higher frequency peak when compared to labial sounds, less VOT.

Alveolar:- Shortened transition upwards or downwards; high frequency peak greater VOT when compared with labial and dental sounds.

Retroflex:- Upward shift and low-frequency peak.

Velar:- Upward shift of transition; midfrequency peak, greater VOT when compared with other sounds.

The representative spectrograms are given below.

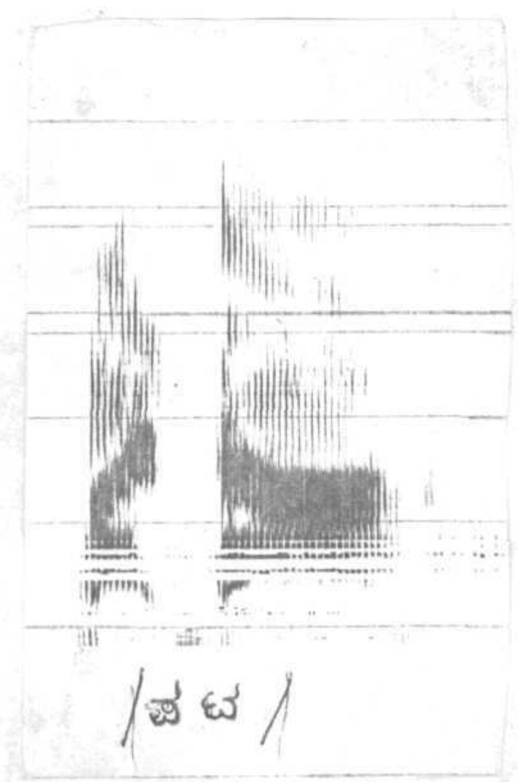


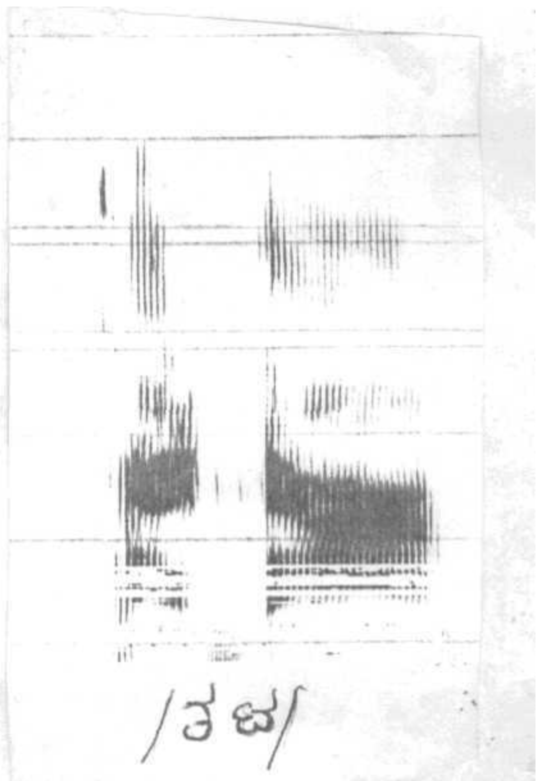
Coronal:- The insepction of the consonants with + and — coronal feature indicate the following acoustic characteristic as distinctive.

1. Gradual upward movement of F_1 and gradual downward movemen of F_2 in + coronal consonants, where as a sudden downward movement of F_1 and sudden upward movement of F_2 in -(voronal.

In acoustic characteristics seen in this feature are a gradual transition of forments.

A representative spectrogram is given below:





Thus the acoustic analysis of minimal pairs in Kannada reveal distinct acoustic characteristics for each of the proposed feature. Therefore hypothesis five stating that "Each of the distinctive feature proposed presents distinct acoustic characteristics", is accepted.

Thus each feature presents the acoustic characteristics typical for that particular feature. This further suppors th hypothesis one stating that "Kannada language has a distinctive feature system" and the hypothesis (5) that the acoustic characteristics of features the present experiment are similar found in to that of acoustic characteristics of distinctive features described for other languages (like in English bv Potter, et al, 1966; Fry, 1979; Danialoff, 1980).

This suppors the view that the distinctive features are universal or in other words it can be stated that the phoneme used in different languages have similar acoustic charactersitics; which points out the fact that the speech mechanism in human beings is same throughout the world.

Thus the distinctive feature system for consonants in Kannada has been established using 8 features. This can be used in study of articulatory behaviour of Kannada speakers.

II. Perceptual Analysis

Part I:-

Analysis:- The response of 30 Kannda listeners to 916 words have been analyzed using a confusion motrix (as shown in Table 2)

A confusion motrix is a motrix in which the stimuli and reponses are portrayed.

31 consonants presented to 30 listeners as they occured in 916 words are presented in vertical axis of the motrix, as stimuli. The same 31 consonants as perceived by 30 listeners and the spoken out responses are represented on the horixontal axis, as response. The matrix is made up of 916 observation of 30 listeners making it 27,480 observations totally.

The number written in each cell is the frequency of occurance of the sound in the response column for the sound shown in the corresponding column of the stimuli. The row sums give the total frequency of stimuli presented and column sums give the total frequency of responses which occurred.

Further, this confusion matrix for 31 consonants in Kannada was sub-divided into voice communication net work of 8 component binary channels of linguistic features; based on 8 features proposed.

Table 2

	k	k^h	g	g^h	c	c^h	j	j^h	ṭ	ṭ^h	ḍ	ḍ^h	ṇ	t	t^h	d	d^h	n	p	p^h	f	b	b^h	m	y	r	l	w	ʃ	s	h	l̥	a	S_T
k	822	3	21											54																				900
k^h	218	576												47					59															900
g	63		833													34																		930
g^h	14		376	463												31	16																	900
c					819		27							19																35				900
c^h	23				286	502	26							21	15															27				900
j	7				38		810									19														26				900
j^h					19		373	482								14														12				900
ṭ	36								711		26			97																				870
ṭ^h					18				267	500	34	14		37																				870
ḍ	16										896	27				39		12																990
ḍ^h	21										264	464	27			64																		840
ṇ													757					83																840
t	29													860		67			16											18				990
t^h	25													231	487	37			8											22				810
d														42		731						67												840
d^h														31		214	532					63												840
n																29		825						16										870
p	23													19					833	11								44						930
p^h														37					241	315	164							23						780
f																																		
b																28			31			794						47						900
b^h																19	26		14			227	485					39						810
m																		63				29		868										960
y																27									839			34						900
r																23										774	87	16						900
l																34											813	29				24		900
w																			52						27			821						900
ʃ					39	12																							682	167				900
s					64	17								51															38	730				900
h																															873		27	900
l̥									14		31																68					697		810
a																																		
	1297	579	1230	463	1283	531	1236	482	992	500	1251	505	784	1546	502	1410	574	983	1254	326	164	1180	485	884	866	774	968	1053	720	1037	873	721	27	27480

Again confusion matrices were formed for each of this linguistic feature. These matrices were four fold motrices. For example: One can construct a four fold confusion motrix by grouping the voiceless sounds together as one stimulus and the voiced sounds as the other and then tabulating the frequency of voiceless responses to voiceless stimuli, of voiceless responses to voiced stimuli, and of voiced response to voiced stimuli; of voiceless responses to voiced stimuli.

	Response	
	Voiced	Voiceless
Voiced		
Stimuli voicless		

In all the confusion matrices thus formed show, the sum of the numbers in a diagonal line indicates the number of correct response, and the numbers scattered around the diagonal like indicates error response.

A measure of co-variance based on information theory (Shannon and Weaver; 1963) was employed to calculate information transmission for a composite phoneme channel and for 8 linguistic distinctive features.

The formula used is:

$$T(x,y) = -P_{ij} \log_2 \frac{P_i \cdot P_j}{P_{ij}}$$

Where

$T_{(x,y)}$ = Information transmission from input variable 'x' to output variable y bits/stimulus.

P_i = n_i / N

P_j = n_j / N

ni = Frequency of stimulus i

nj = Frequency of response j

nij = Frequency of joint occurrence of stimulus, i and reponse, j in a sample of N observations.

N = Total number of observations.

In table (2&4) cell entries are 'nij'; row sums are 'ni'; column sums are 'nj' and N is 27480.

To calculate $T_{(x,y)}$

For example :

		Response		
		j_1	j_2	
Stimulus	i_1	a	b	a + b
	i_2	c	d	C ++d
		a + c	b + d	

Where $N = a + b + c + d$.

To find information of stimulus 8i8, use the above mentioned formula of co-variance.

$$T_{(x,y)} = - \left[\frac{a}{N} \log_2 \frac{\frac{a+c}{N} \times \frac{a+b}{N}}{a/N} + \frac{b}{N} \log_2 \frac{\frac{a+b}{N} \times \frac{b+d}{N}}{b/N} + \frac{c}{N} \log_2 \frac{\frac{a+c}{N} \times \frac{c+d}{N}}{c/N} + \frac{d}{N} \log_2 \frac{\frac{b+d}{N} \times \frac{c+d}{N}}{d/N} \right]$$

Thus the information value carried by each feature was calculated.

Results and discussion:- The percentage of correct response to 916 words by 30 Kannada listeners was found to be 21%
By observing the pattern of error responses scattered around the diagnoal line, it can be inferred that when the two sounds differ in nore number of features, the confusions were less; and when the two sounds differed in less number of feature, then the confusions were more. For eg., More confusion for the phonemes /p/ and /b/ and less confusions for the sounds /p/ and /g/, were observed.

Table :3

Table showing information transmission in bits/stimulus for 8 linguistic distinctive features and ranking of the features according to the amount of information transferred in case of Kannada listeners:-

Sl.No.	Ranking	Feature	Information Transmission in bits/stimulus
1	I	Voicing	0.8024
2	II	Coronal	0.7771
3	III	Stridency	0.712
4	IV	Anterior	0.6837
5	v	Continuent	0.6595
6	VI	Nasality	0.4284
7	VII	Aspiration	0.3498
8	VIII	Lateral	0.2816

Total transmission in bits/stimulus = 4.6948.

Composite phoneme cannel transmission = 3.2

By above indicated results one can know that several features play an important role in speech sound perception. These features work independent of each other in the perception of speech sounds. But, actually these features are not completely independent. This is supported by the finding that composite phoneme channel transmits bits/ /stimulus information; where as the total of the information transmission by 8 features yielded information transmission of 4.6948 bits/stimulus which is greater than that for a composite phoneme channel. This is due to 'cross talk' or 'overlap' between components channels. The difference is because of redundancy of the language.

The information transmission values for different features, in table 3 , indicate that all the proposed features do not have equal importance in speech sound perception. Some distinctive features transmit more information than the others. Hence the hypothesis. "All distinctive feature do not carry equal amount of information" is accepted.

The ranking of the features according to the amount of information transmitted indicates that the feature "voicing" is the strongest feature and the feature 'lateral' is the weakest feature. Miller and Nicely (1955) study also shows that voicing is the stongest feature in English.

The findings of this study are in agreement with other apriori studies that "while all the of the above studies prove unambiguously that all features of a given system are not equally important, they do not agree regarding the explanatory powers of a given feature system". (Singh, 1976).

Part II

Analysis:- Analysis by generating confusion materices was carried out as described in Part I, for 916 words containing 31 Kannada consonants presented to 30 non-Kannada listeners (as shown in table FOUR)

Results and discussion:- The percentage of correct responses for 27480 observations by 30 non Kannada listeners by 30 non Kannada listeners was calculated. This was found to be 24%. The percentage is lesser than that of Kannada listeners. Although the number of erros is more in non-kannada listeners, the pattern of errors for both the groups is similar. The sounds, which share more features are confused more often than the sounds which share less features. This makes clear that non-kannada listeners use the same set of distinctive features to identify speech sounds. The results might have been influenced by the select of subjects. The nonKannada group had Hindi or one of the other dravidian language (Tamil, Telugu and Malayalam) as their mother tonge. Eventhoug the non-Kannada listeners

Table 4

S \ R.	k	kʰ	g	gʰ	c	cʰ	j	jʰ	ṭ	ṭʰ	ḍ	ḍʰ	ṇ	t	tʰ	d	dʰ	n	p	pʰ	f	b	bʰ	m	y	r	l	w	ʃ	s	h	ḷ	e	S_T
k	781	6	33						5					67					8															900
kʰ	348	483				8								44					13												4			900
g	26		894	6																					4									930
gʰ	6		423	366			8	3									78	4	5				7											900
c	7				771	8	78																		4					32				900
cʰ					257	585	32	12																						14				900
j					38		827																		6					29				900
jʰ					24		298	571																						7				900
ṭ	27								690		19			108	4	15			7															870
ṭʰ									269	366		8		197	26	4																		870
ḍ	23								45		808			18		70																26		990
ḍʰ									17	36	358	359					53															17		840
ṇ									18				599	27				187												9				840
t	27								52					844	6	23			18							7	4	9						990
tʰ	43					6			11					289	424		18		6											13				810
d			18								14					783						9						16						840
dʰ			12								38				17	211	519								7			36						840
n													23					847																870
p	21								36		4			54					774			22						19						930
pʰ	6				4									28			17		162	296	193		26					48						780
b																21			12			821						46						900
bʰ																22	37					267	427	6				51						[illegible]
m																			23					925	12									[illegible]
y																									868	18							14	900
r														39		16										758	86						9	900
l																26								8			842					24		900
w			18								21								14			56						762				29		900
ʃ					37																								737	126				900
s					87									31															54	728				900
h																												18	9	11	803		59	900
ḷ									22		38														12		106 16					632 32		810
	1315	489	1398	372	1218	607	1243	586	1165	402	1300	367	622	1746	477	1191	722	1038	1042	296	193	1175	460	939	913	775	1038	1005	800	969	807	728	82	27400

did not know the kannda language to speak to write or to read, they were exposed to Kannada language nearly for 6 months.

Somasundaram (1972) in his study of distinctive features states that, all the four major dravidian languages has nine distinctive features in common.

The information transmission was calculated in terms of bits/stimulus for composite phoneme channel and individual features. The features were ranked according to the amount of information transmitted from the highest to the lowest amount. The feature 'voice' holding the highest rank and the feature 'lateral' being the lowest. The results of information transfer analysis are presented in Table.5.

When the ranking was compared to that of the Kannada listeners it was found that the ranking was same. There were no difference in ranking.

The finding of this part of the experiment indicates that there is similarity in the performance of Kannada and Non-Kannada subjects. This may be because of the use of almost the same set of distinctive features in the language of Non-Kannada subjects as in Kannada language. Thus the findings indicate the possible existence of universal distinctive features (Chomsky and Halle, 1968; Meyuk, 1968).

Table:5

Table showing information transmission in bits/stimulus for 8 linguistic distinctive features and ranking of the features according to the amount of information transfer in non-kannada listeners:

Sl.No.	Ranking	Features	Information Transmission bits/stimulus
1	I	Voicing	0.7766
2	II	Coronal	0.7465
3	III	Stridency	0.7201
4	IV	Anterior	0.661
5	V	Continuent	0.5986
6	VI	Nasality	0.4235
7	VII	Aspiration	0.3465
8	VIII	Lateral	0.2719

Total transmission in bits/stimulus = 4.5447

Composite phoneme channel transmission = 3.6

Table :6

Table showing comparison of ranking between Kannada a6d non Kannada listerners.

Sl.No.	Ranking	Features Kannada Listeners	Features Non-Kannada Listeners
1	I	Voicing	Voicing
2	II	Coronal	Coronal
3	III	Strident	Strident
4	IV	Anterior	Anterior
5	V	Continuent	Continuent
6	VI	Nasality	Nasality
7	VII	Aspiration	Aspiration
8	VIII	Lateral	Lateral

Therefore the hypothesis six stating that "no significant difference will be found in the listening performance of Kannada and non-Kannada subjects when words with minimal differences are presen ed in quiet situation" is accepted.

The results of perceptual analysis of the proposed distinctive feature system for consonants in Kannada supports the existence of these proposed features in speech sound perception with some amoung of redundancy; and shows the existence of distinctive feature system in Kannada. This supports the hypothesis stating that "Kannada language has a distinctive feature system".

The existing distinctive feature system has 8 distinctive features proposed based on phonetic discription of Kannada consonants. This supports the hypothesis two stating that "It is possible to propose distinctive features based on phonetic description of Kannada consonants".

These proposed distinctive features have been identified acoustically as distinctive.

Thus it is possible to analyze the consonants in Kannada language using these 8 distinctive features. Therefore the hypothesis three stating that consonants in Kannada language are made of the following distinctive features:-

1) Voicing 2) Nasality 3) Anterior 4) Coronal
5) Stridency 6) Continuent 7) Aspiration 8) Lateral
isaccepted.

The method used in this study to validates the existence of particular set of distinctive features in a language seems to be simple and useful as the findings of the perceptual evaluations have been confirmed by the acoust analysis. Therefore this method can be used to propose and evaluate the distinctive features that may be present in a particular language.

The present study has several applications and implications as follows:

1. The distinctive feature system presented here may be used to assess the severity, and type of misarticulation in case of Kannada speakers.
2. This distinctive feature system can be used to choose the sounds to be corrected in articulation therapy.
3. This system can be used in the construction of a Kannada articulation test.
4. This can be used to study the acquisition of Kannada . phonology by children.
5. This information can be used in designing telecommunication systems for the use of Kannada speakers, giving priorty to see the features that carry maximum information are not missed or distorted during transmission.

In the light of the findings of the recent investigations on distinctive features and the present study it becomes necessary to describe the ultimate units of a language in terms of distinctive features.

For speech pathologist the distinctive feature system seems to be a very useful tool in describing the articulatory behaviour in various cases; in classifying, and in planning therapy and in assessing the cases of misarticulation.

It may be possible to develop a classificatory system to classify the cases of misarticulation based on distinctive features i.e. considering the information value carried by the feature missing or misplaced and the distance between the feature to be produced and feature that is being actually produced.

Attempts have already been made to study various languages using distinctive feature system of that particular language. A study to describe Kannada language using the present distinctive features may be of use to linguist and and speech pathologist and speech scientist.

Thus the findings of the present study are useful in better understanding of Kannada language.

CHAPTER - 5

SUMMARY AND CONCLUSIONS:-

Phoneme was considered to be the smallest unit of language (Bloomfied, 1936). This traditional view has undergone a metamorphosis with the advent of the concept of distinctive feature. Distinctive features are now considered to be the physical and psychological realities of a phoneme" (Singh, 1976). This defination thus clearly brings to light the two aspect of the features - the perceptual and the acoustic.

The establishment of a distinctive feature system has been achieved by various methodologies such as the perceptual method, (Miller and Nicely, 1955) articulatory method (Chomsky and Halle, 1968) and acoustic method (Jakobson, Fant and Halle, 1952).

Distinctive features serve many purposes. They can be used;

1. to study the phonology of a language
2. to study the acquisition of phonology in children
3. in assessment and management of articulation disorders
4. to study the perception of individuals who are both normals and hard of hearing.

An attempt has been made to describe Hindi language features (Ahmed and Agrawal, 1969). Somasundaran (1972) has attempted to compare phonology of four languages -

Tamil, Kannada, Telugu and Malayalam, using distinctive feature system. However this was not an experimental study. Falguni (1982) has established a distinctive feature system for Gujarathi consonants. Distinctive features of Malayalam consonants have been proposed by Arati (1983). The present study aimed at establishing a distinctive feature system for Kannada consonants.

458 minimal word pairs were prepared using 31 Kannada consonants. These pairs were prepared such that, at least there was one feature difference between the two consonants of a pairs of words. The perceptual analysis carried out in two stages:(1) The minimal pairs were presented to a group of 30 subjects, whose mother tongue and native language was Kannada. Subjects had to speak out what they heard. (2) The same stimuli were presented to a group of 30 listeners who were non-kannadigas. For these subjects, the Kannada language was niether mother tongue nor native language.

The 37 words pairs from the list were selected and spectrographic analysis was done.

The perceptual data was analyzed using confusion matrices and by calculating information content of each feature.

The following conclusions were drawn from the study:

1. Kannada language has a distinctive feature system.
2. It is possible to propose a distinctive feature system to Kannada language based phonemic analysis.
3. Consonants in Kannada are made of the following features:
   (a) Voicing (b) Nasality (c) Continuent
   (d) Stridency (e) Coronal (f) Anterior
   (g) Aspiration (h) Lateral.
4. Information value of each feature differs.
5. Each feature has distinctive acoustic characteristics.
6. Significant difference was not found between the listening performance of Kannada and non-Kannada speakers, when words with minimal differences were presented in a quiet situation.

Implications:-

1. The distinctive feature system thus established gives an indepth analysis into the phonology of Kannada.
2. It can be used to study the phonological acquisition of Kannada in children.
3. It has major implication to articulatory disorders both at the testing and at the therapentic level.
4. It allows the study of perception of those with Kannada as their mother tongue and groups whose mother tongue was not Kannada.
5. The feature system will be helpful in classifying articulation disorders in order of severeity; especially using the substitution analysis which may indicate depending upon the-substitution, it's severiety.

6. Speech discrimination tests can be developed in Kannada.

7. An articulation drill book in Kannada can be prepared based on this.

8. It can be used in the development of speech synthesis in Kannada.

9. It can be used to improve the telecommunication systems for transmission of Kannada.

Recommendations:-

1. Further study can be done on substitution analysis that is which of the features are substituted by the other features.

2. An articulation test in Kannada can be developed on the basis of the distinctive feature system.

3. Distinctive feature system can be developed for vowels in Kannada.

4. To study the behaviour of non-Kannada speakers as listeners ,with various mother-tongues, to Kannada speech sounds.

5. The present distinctive feature system can be further validated using other methods of D.F. Analysis.

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APPENDIX

1. Deffination of Distinctive Features proposed for Kannada Consonants.
2. Phonemes of Kannada Language.
3. Word List used in this study.
4. Tree Digram.
5. Distinctive Feature of Kannada Consonants.
6. Unit Difference for 31 Consonants based on Appendix 5.
7. Photograph of Spectrograph- Instrument used in the study.

APPENDIX - 1

Definition of Distinctive Features Proposed for Kannada Consonants;-

1. Voicing:- In the production of + Voicing consonants the vocal folds vibrate; and in the production of - voicing consonants vocal folds do not vibrate.

   Eg:- + Voicing:- /g/ /g^h/, / j / /j^h/,/d//d^h/,/n/ /d/ /d^h/, /n/,/b/b^h/,/m/,/y/,/r/, /l/,/w/,/l/

   - Voicing:- /k/,/k^h/,/c/,/c^h/,/t/,/t^h/,/t/ /t^h/,/p/,/p^h//s/,/s/,/h/

2. Cbrongl:- The + coronal sounds produced with the blade of the tongue raised from its neutral position; and -coronal sounds are produced with the blade of the tongue in neutral position.

   Eg:- + Coronal :- /c/,/c^h/,/j/,/j^h/,/t/,/t^h/,/d/, /d^h/,/n/,/t/,/t^h/d/ /d^h/ / n / , /y/,/r/,/3/,/s/,/s/,/l/

   - Coronal:- /k/,/k^h/,/g/,/g^h/,/p/,/p^h/,/b/,/b^h/ /m/,/w/,/h/

3. Strident:- The + strident consonants are marked acoustically by greater noisiness.

   Eg:- . Strident:- /s/,/s/,/c/,/c^h/,/j/,/j^h/,/h/

4. Anterior:- All the front sounds are known as'+ anterior' i.e., the bilabial, labio dental, dental, and alveolar sounds are * anterior sounds. The palatal, retroflex velar and glottal founds are '- anterior sounds'.

Eg:- + Anterior:- /t/, /t^h/,/d/, /d^h/, /n/, /p/, /p^h/,
/a/, /r/, /l/, /w/, /s/.
- Anterior:- /k/, /k^h/, /g/, /g^h/, /c/, /c^h/, / j /,
/j^h/, /t/, /t^h/, /d/, /d^h/, /n/, /y/
/s/, /h/, /l/.

5. Contingent:- The + continuent consonants are produced with the constriction in the vocal tract regulated in such a way that complete closure or blocking of air passage never occurs.

Eg:- /y/, /r/, /l/, /w/, /s/, / s / , /h/ /l/

6. Nasal:- + Nasal consonants are produced with the lowered velum and - nasal consonants are produced with the raised velum.

Eg:- + nasal:- /n/, /n/, /m/

7. Aspiration:-

Eg:- + Aspiration:- /k^h/, /g^h/,/c^h/, /j^h/, /t^h/, /d^h/, /t^h/
/d^h/, /p^h/, /b^h/,

8. Lateral:- The + lateral consonants are produced by lowering the mid section of the tongue.

Eg:- + lateral:- /l/ and /l/

APPENDIX - 2

Phonemes of Kannada Language

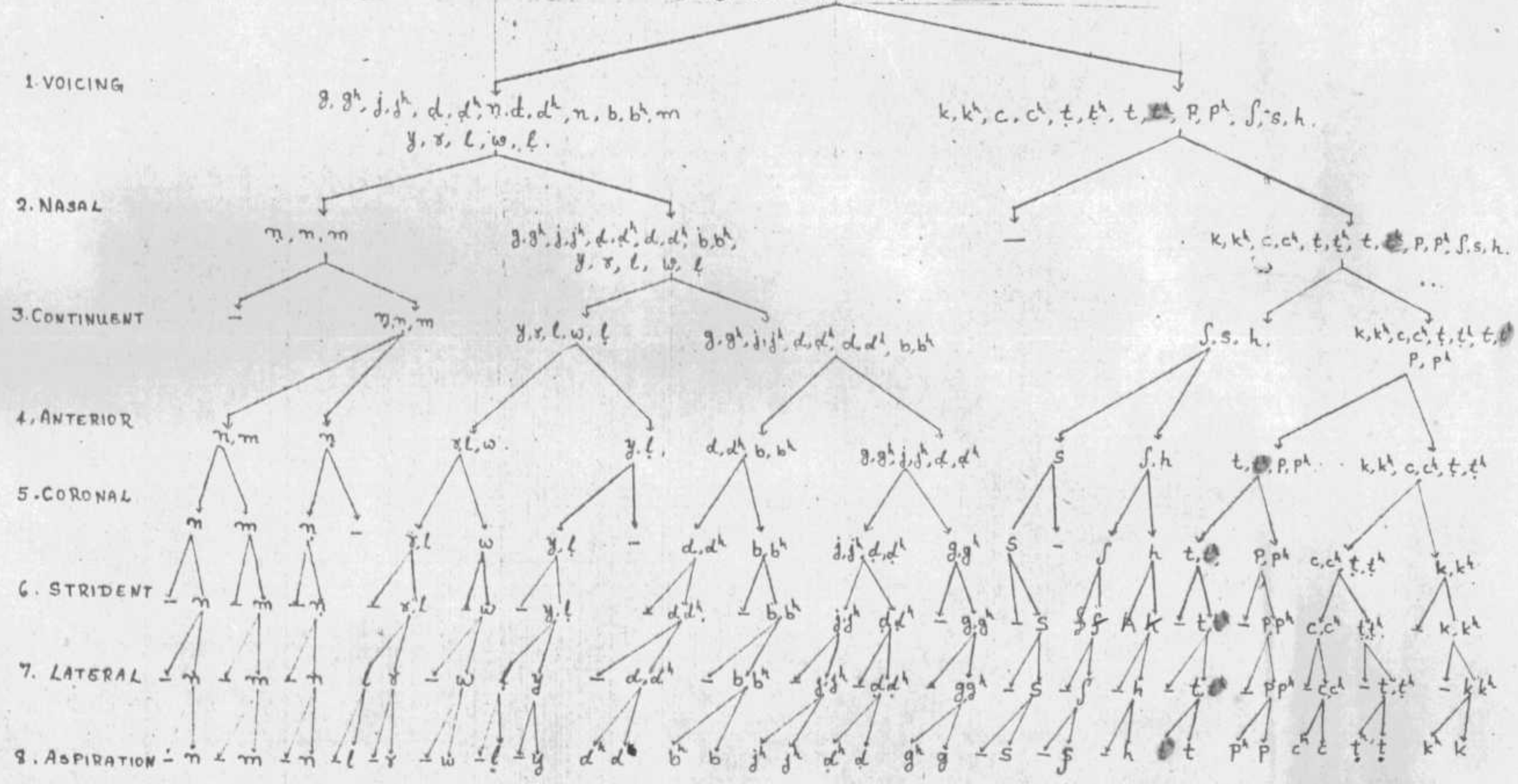
Manner of Articulation	Vl/Vd	Bilabial As	Bilabial UnAs	Detnal As	Detnal UnAs	Retroflex As	Retroflex UnAs	Palatal As	Palatal UnAs	Velar As	Velar UnAs	Gl tt
Stops	Vl	p^h	p	t^h	t	ṭ^h	ṭ	c^h	c	k^h	k	
	Vd	b^h	b	d^h	d	ḍ^h	ḍ	j^h	j	g^h	g	
Fricatives	Vl				s		ṣ		ś			h
	Vd											↓
Nasals			m		n		ṇ		ñ		ṅ	
Laterals					l		ḷ					
Trills					r							
Continuents			w						y			

Vl: Voice less   As: Aspiration

Vd: Voiced   unAs: Unaspiration

APPENDIX-4: TREE DIAGRAM.

31 CONSONANTS OF KANNADA:-



APPENDIX - 5

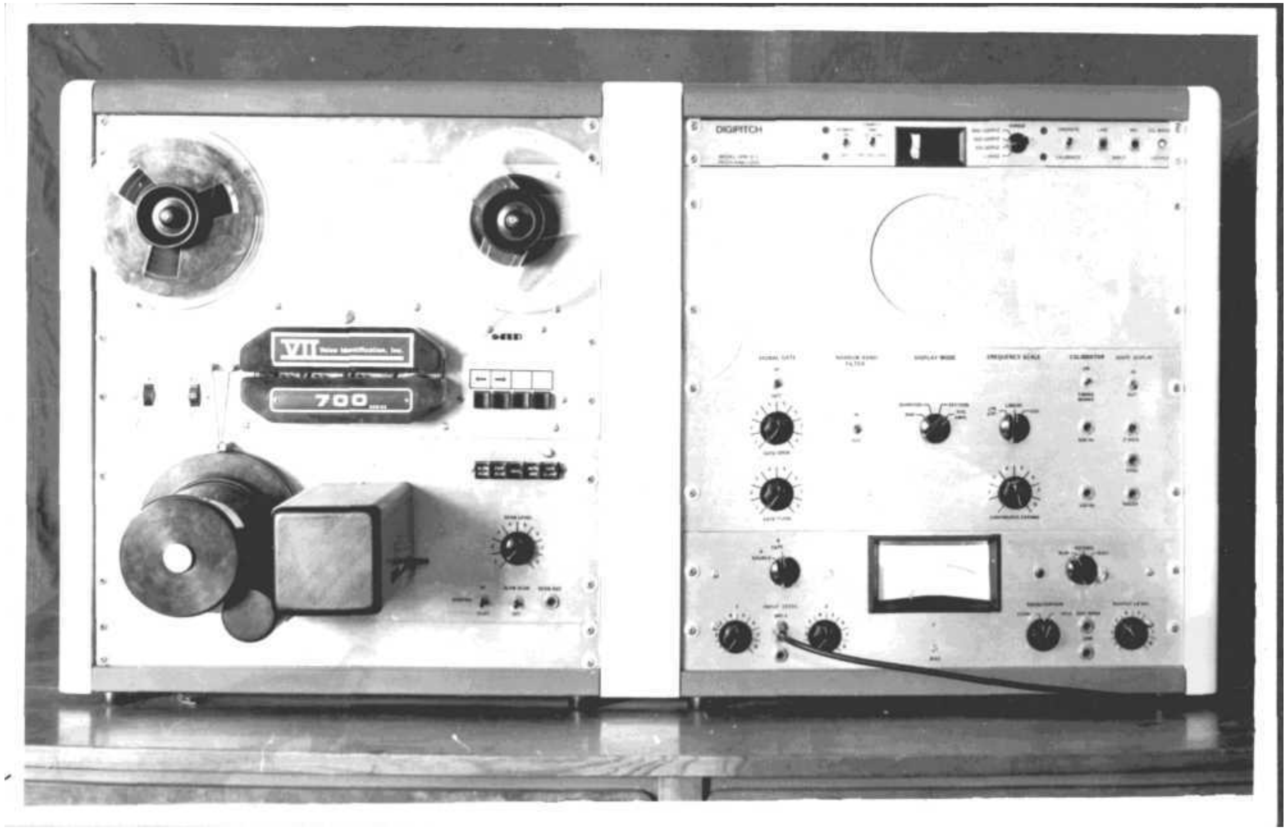
Distinctive features of Kannada Consonants

Sounds	k	k^h	g	g^h	c	c^h	j	j^h	ṭ	$ṭ^h$	ḍ	$ḍ^h$	ṇ	t	t^h
Voicing	-	-	+	+	-	-	+	+	-	-	+	+	+	-	-
Nasal	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Continuent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anterior	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Coronal	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+
Strident	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-
Lateral	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aspiration	-	+	-	+	-	+	-	+	-	+	-	+	-	-	+

Sounds	d	d^h	n	p	p^h	b	b^h	m	y	r	l	w	ʃ	s	h	ḷ
Voicing	+	+	+	-	-	+	+	+	+	+	+	+	-	-	-	+
Nasal	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
Continuent	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+
Anterior	+	+	+	+	+	+	+	+	-	[illegible]	+	+	-	+	-	-
Coronal	+	+	+	-	-	-	-	-	+	+	+	-	+	+	-	+
Strident	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-
Lateral	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+
Aspiration	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-

Appendix 6 Unit of Difference for 3 consonants based on Appendex -5

	k	kʰ	g	gʰ	c	cʰ	j	jʰ	ṭ	ṭʰ	ḍ	ḍʰ	ṇ	t	tʰ	d	dʰ	n	p	pʰ	b	bʰ	m	y	r	l	v	ʃ	s	h	ḷ
k	0																														
kʰ	1	0																													
g	1	2	0																												
gʰ	2	1	1	0																											
c	2	3	3	4	0																										
cʰ	3	2	4	3	1	0																									
j	3	4	2	3	1	2	0																								
jʰ	4	3	3	2	2	1	1	0																							
ṭ	1	2	2	3	1	2	2	3	0																						
ṭʰ	2	1	3	2	2	1	3	2	1	0																					
ḍ	2	3	1	2	2	3	1	2	1	2	0																				
ḍʰ	3	2	2	1	3	2	2	1	2	1	1	0																			
ṇ	3	4	2	3	3	4	2	3	2	3	1	2	0																		
t	[illegible]	3	3	4	2	3	3	4	1	2	2	3	3	0																	
tʰ	3	2	4	3	3	2	4	3	2	1	3	2	4	1	0																
d	3	4	2	3	3	4	2	3	2	3	1	2	3	1	2	0															
dʰ	4	3	3	2	4	3	3	2	3	2	2	1	2	2	1	1	0														
n	4	5	3	4	4	5	3	4	3	4	2	3	1	2	3	1	2	0													
p	1	2	2	3	3	4	4	5	2	3	3	4	4	1	2	2	3	2	0												
pʰ	2	1	3	2	4	3	5	4	3	2	4	3	5	2	1	3	2	3	1	0											
b	2	3	1	2	4	5	3	4	3	4	2	3	3	2	3	1	2	2	1	2	0										
bʰ	3	2	2	1	5	4	4	3	4	3	3	2	4	3	2	2	1	3	2	1	1	0									
m	3	4	2	3	5	6	4	5	4	5	3	4	2	3	4	2	3	1	2	3	1	2	0								
y	3	4	2	3	3	4	2	3	2	3	1	2	2	3	4	2	3	3	4	5	3	4	4	0							
r	4	5	3	4	4	5	3	4	3	4	2	3	3	2	3	1	2	2	3	4	2	3	3	1	0						
l	5	6	4	5	5	6	4	5	4	5	3	4	4	3	4	2	3	3	4	5	3	4	4	2	1	0					
w	3	4	2	3	5	6	4	5	4	5	3	4	4	3	4	2	3	3	2	3	1	2	2	2	1	2	0				
ʃ	3	4	4	5	1	2	2	3	2	3	3	4	4	3	4	4	5	5	4	5	3	4	4	2	3	4	4	0			
s	4	5	5	6	2	3	3	4	3	4	4	5	5	2	3	3	4	4	3	4	2	3	3	3	2	3	3	1	0		
h	2	3	3	4	2	3	3	4	3	4	4	5	5	4	5	5	6	6	3	4	2	3	3	3	4	5	3	1	2	0	
ḷ	4	5	3	4	4	5	3	4	3	4	2	3	3	4	5	3	4	5	5	6	4	5	5	1	2	1	3	3	4	4	0



Appendix-7 Spectrograph VIInc 700' series- Instrument use in the study