DISTINCTIVE FEATURE ANALYSIS OF KANNADA CONSONANTS

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The language has several levels, like Semantic, Syntactic, Morphemic and Phonemic levels. The Phonemic level is the lowest and most fundamental level.

Complex objects and events have sub-units or recognizable properties. These properties are termed as features. The features which help to distinguish between two entities are called as distinctive features.

The present study is an attempt to analyze the distinctive features of Kannada consonants.

Earlier it was believed that phoneme was the smallest unit of language and it could not be divided any further. Jackobson et. al. (1952) proposed a new theory which is known as Pbenemic theory and said that the basic unit of phoneme is, it's constituent properties. These basic units are termed as features and the units that bring about, distinction between two phonemes are called 'distinctive features'. "The distinctive features are the ultimate distinctive entities ot language The distinctive features combine into one simultaneous or concurrent bundle to form a phoneme (Jackobson, Fant and Halle, 1951)

The distinctive feature can be defined as the physical (articulatory or acoustic) and psychological (perceptual) realities of phoneme. Each phoneme can be described and differentiated in terms of;

1) articulatory features, namely the place of articulation, and the manner of articulation ;

2) acoustic features, namely frequency, intensity and durati«n of speech sounds ; and

3) perceptual features which are the results of the auditory discrimination between the phonemes.

The frame work of distinctive features is *a* promising tool to Speech Pathologists and Audiologists in handling various speech and hearing problems. This approach has bean found to be useful in description of various articulatory behaviour (Mc Reynolds and Huston, 1971 ; Castellow, 1975), in diagnosis, prognosis and treatment of articulatory deviation (Weber, 1970; Kamara and Kamara, ; Singh, 1974), in testing speech sound perception (Danhaver and Singh, 1975; Danhaver et. al. 1978), in studying language acquisition and phonological acquisition (Menyuk, 1968) and in studying hemispheric specializatioa (Studdert-Kennedy and Shankveiler, 1970).

Several attempts have been made to describe various lanruages of the world using distinctive features. Different systems of distinctive features have been proposed, (Jackobson et. al , 1951 ; Chomsky and Halle, 1968; Miller and Nicelly, 1955, Singh and Becker, 1972, base. on different methods of extracting features. These methods are,

1) The Acoustic Method (Jackobson, Fant and Halle, 1952)

2) The Articulatory Method (Chomsky and Halle, 1968) and

3) The Perceptual Method (Miller and Nicely 1955).

An attempt has been made to describe Hindi language using distinetive features (Ahmed and Agrawal, 1969). Somasundaran (1972) has attempted to compare phonology of four languages, Tamil, Telugu, Kannada and Malayalam using a feature system. However, this is not an experimental study. Valantine (1977) proposed a system for classifying the phonological system of Malayalam. Fhalguni (!982) established a distinctive feature system for consonants in Gujarati Arati (1983) attempted to establish distinctive feature system for Malayalam consonants. Both Fhalguni (1982) and Arati (1983) used experimental methods to establish distinctive features.

To facilitate finer analysis of the phonology of language and it's disorder, an attempt has been made to establish a distinctive feature system for consonants in Kannada language.

The purpose of the study was (1) To establish a distinctive feature system for consonants in Kannada language, (2) To identify acoustic correlates of the proposed feature system, (3) To find out the information carried by each feature in perception of speech sounds, (4) To compare perception of speech sound by native and non-native listeners of Kannada in order to test feature universality.

METHOD:

A distinctive feature system for consonants in Kannada has been proposed based on a distinctive feature system proposed by Chomsky and Halle (1968). The proposed distinctive feature system consists of following features: (1) Voicing, (2) Nasality, (3) Continuent, (4) Stridency, (5) Coronal, (6) Anterior, (7) Aspiration, (8) Lateral. All the features have binary specification. The presence of the feature is indicated by +, and absence of feature is indicated by —.

Two experiments were carried out in order to find acoustic and perceptual correlates of the proposed feature system. They are : (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 atleast by one feature.

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

(c) Procedure : The 37 minimal word pairs were recorded using the tape recorder of speech-spectrograph on a professional tape. The speaker had 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. This recording was done in a sound treated room.

The wide band spectrograms for each word pair were obtained using 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 concentration of energy is seen (iii) Presence ef periodic or aperiodic energy.

2. Perceptual Analysis : This experiment has two parts.

PART I

(a) Stimuli: Consisted of 916 words derived from 458 minimal pairs. The minimal pairs were recorded in a random order. The words were recorded and played using COSMIC recording deck.

(b) Subjects". The subjects were 15 males and 15 females. They were college students having Kannada as their mother tongue. They ranged in age from 18 to 23 years. They had no history of speech and hearing problem. They could read and write Kannada.

(c) Procedure ; The tape recorded wards were played through ear phones, to each listener in a quiet room. The following instructions were given in Kanaada languaege.

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

(Now, you are going to hear several Kannada word 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 Panasonic 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 ward presented was substituted ©r omitted or distorted.

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

PART II

a) Stimuli: As in part[

b) Subjects: 15 males and 15 females 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 instructions were given in English.

The same procedure was follwed for all 30 subjects.

(d) Scoring : The spoken responses of all 30 subjects were scored as in Part-I.

Results and Discussion:

1. Acoustic Analysis : The close inspection of wide band spectrograms for 37 minimal word pairs was carried out to identify distinct acoustic correlates for each feature proposed.

The distinct acoustic correlates for each feature, proposed has been summarised in Table-1 as follows :

The findings of the present experiment are similar to that of acoustie characteristics of distinctive features described for other languages (like in English, by Fry, 1979 ; Potter et. al, 1966 ; and in Gujarati by Fhalguni (1982)....etc.)

This supports the view that distinctive features are universal. It can be stated that the phonemes used in different languages have similar acoustic characteristics, which points-out the fact that the speech mechanism and production in human beings is same throughout the world.

2. Perceptual Analysis:

Part I: The responses of 30 Kannada listeners have been analyzed using a confusion matrix as in Table-2.

The vertical axis represent ; stimuli and the horizantal axis represents responses. Each cell of the matrix represents the joint occurrence of a corresponding stimulus and response. The total number of observations pooled in this matrix were 27,480.

Further this matrix for 31 consonants in Kannada has been subdivided into voice communication network of 8 component binary channels of linguistic features based on 8 features proposed. Again four fold confusion matrices were formed for each of the features.

In all confusion matrices formed the sum number in & diagonal line indicates the number of correct responses and the number scattered around the diagonal indicates error respenses.

A measure of co-variance based on information theory (Shaanon and Weaver, 1953) was employed to calculate information transmission for a composite phoneme channel and for 8 linguistic features.

TABLE- 1

Table showing the acoustic characteristics of each .feature *(+)* when it is present:

Sl. No.	Feature (+)	1 Acoustic Characteristics
1.	Voicing	(i) Regular vertical striations in low frequency region occaring simultaneously with the burst. (ii) Decreased burst intensity when compared to-ils voiceless counterpart.
2.	Nasality	(i) Low frequency formant (ii) Tail like appearance
3.	Continuant	(i) Gradual onset of intensity (ii) Longer duration of vibration (iii) Absence of spike (burst of energy)
4.	Stridency	(i) High frequency aperiodic portion of a long duration.
5.	Aspiration	(i) Extra Energy concentration in aperiodic portion of the consonants at high frequency
6.	Lateral	(i) Continuous periodic portion (ii) small gaps
7.	Coronal	(i) Gradual upward movemnt of F1 and gradual downward movement of F2.
8.	Anterior:	It is not possible to differentiate "Anterior' and 'Non-anterior' as rhese sounds vary in terms of duration of VOT and transition of formants. Hence it is explained, based on place of articulation.
	a) Labial	Downward transition, low frequenry peak and very less VOT.
	b) Dental	Upward transition, higher frequency peak when compared to labial sounds, less VOT.
	c) Alveolar	Shortened transition upward or downwards; high frequency peak greater VOT than compared with labial and dental sounds.
	d) Retroflex	Upward shift and low frequency peak
	e) Velar	Upward shift of transition ; mid frequency peak. greater VOT when compared with other sounds.

The formula was, $T_{(x,y)} = \sum Pij \log_2 \frac{Pi\ Pj}{Pij}$

T = Information transmission from input variable x to output (x,y) variable y in bits/stimulus

ni = Frequency of stimulus i,

nj = Frequency of response j,

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

Pi = ni/N

pj = nj/N

Pij = nij/N

In Table-2 and 4, all cell entries are nij; row sums are ni; column sums are nj and N is 27,480.

The percentage of correct responses for 916 words by 30 Kannada listeners was found to be 79%. The observation of pattern of error response revealed that when the two sounds share more number of features, the confusions are more and when the two sounds have very few number of features in common the confusions are less.

Table-3, gives information transmission for a composite phoneme channel and 8 component channels of linguistic features in bits/stimulus. The table also depicts the ranking of linguistic features according to the amount of information transmission from highest to lowest, the feature 'voicing' having the highest information transfer and the feature 'lateral' having the lowest value of information transfer.

The results suggest the semi-independence of features in carrying information for the perception of Speech sounds. Certain amount of redundancy was indicated by the difference be ween information transfer for composite phoneme channel and the sum of the information transfer for linguistic features — the latter being more.

TABLE-3

Table showing information transmission in bits/stimulus for 8 linguistic features and ranking of the features according to the amount of information transfer in Kannada listeners.

SI. 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	Continuant	0.6595
6.	VI	Nasality	0 4284
7.	VII	Aspiration	0 3498
8	VIII	Lateral	0.2816

Total Transmission iu bits/stimulus =4.6948

Composite phoneme channel transmission =3.2

The findings also point to the fact that all the proposed distinctive features do not have equal importance in speech sound perception. Some features transmit more information than others. The ranking of the features was similar to that found in experiment carried out by Miller and Nicely (1955). This suggests a possible existance of universal features.

Part II : The responses of 30 non-Kannada listeners to **916** words were analyzed on a confusion matrix, as shown in Table-4.

The percentage of correct response by non-Kannada listeners was found to be 76%. Although the perecentage of error response is more, the pattern of errors is more or less the same. The sounds which share more number of

features are confused more often than the sounds which share less number of features.

Table-5 shows the amount of information transmission or a composite phoneme channel and 8 linguistic features. The table also depicts the ranking of features according to amount of information transmitted from highest to lowest ; voicing having the highest information transfer and lateral having the lowest.

The result of Part-TI also indicate semi-independence of features and relative importance of features in speech sound perception. The ranking order of features in both the groups was same, when compared This highlights the point that listeners of Kannada and non-Kannada must be using the same set of features for the perception of speech sounds. This supports the notion of universality of features as proposed by Menyuk (1968).

TABLE-5

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

SI. No.	Ranking	Features	Information Transmission in bits/stimulus
1.	**I**	Voicing	0.7766
2.	II	Coronal	0.7465
3.	III	Stridency	0.7201
4.	IV	Anterior	0. 661
5.	V	Continuant	05986
6.	VI	Nasality	0.4235
7.	VII	Aspiration	0.3465
8.	VIII	Letaral	0.2719

Total transmission in bits/stimulus = 4.5447
Composite phoneme channel transmission = 36

Finally, the results of tills srudy validat; the proposed distintive features by identifying acoustic and perceptual correlates. Further an existence of universal feature system can be speculated based on perceptual and acoustic analysis.

The major conclusions drawn from she present investigation are as fallows :

1. Distinctive feature system can be proposed based on phonetic descriptives of Kannada language.

2. There are distinct acoustic characteristics for each of the feature proposed.

3 All the features do not have equal importance in carrying information for speech perception, some carry more information than others.

4. Non-Kannada subjects show the same pattern of errors in listening performance as Kannada subjects and they show same ranking of features in carrying information for speech perception.

The findings of present experiment may be helpful to Speech Pathologists and Audiolognts who deal with speech, language and hearing disorders in individuals having Kannada as their mother tongue.

It may aid in (1) Diagnosis, (2) Prognosis, (3) Judging severity, (4) Planning treatment, and (5) Measuring progress.

The development of feature system in Kannada language provides owning to- the finer study of language.