Perception and Production of Emotive Intonation in Individuals with Right Hemisphere Damage

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MAY 2001

CERTIFICATE

This is to certify that this dissertation ***entitled "Perception and production of emotive intonation in individuals with Right Hemisphere Damage",*** is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register No.M9910.

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CERTIFICATE

This is to certify that this dissertation ***entitled "Perception and production of emotive intonation in individuals with Right Hemisphere Damage"*** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier in any other University for the award of any Diploma or Degree.

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DECLARATION

This dissertation entitled ***"Perception and production of emotive intonation in individuals with Right Hemisphere Damage"*** is the result of my own study under the guidance of Dr.R.Manjula, Lecturer, Department of Speech Pathology, All India Institute of Speech & Hearing, Mysore, and has not been submitted earlier in any other University for the award of Diploma or Degree.

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INTRODUCTION

"I understand a fury in your words, but not the words ."

-Shakespeare (Othello)

This quote captures the role of prosody in speech. By attending to an utterance's prosodic contour, which is characterized by variations in pitch(frequency), loudness (amplitude), time (duration), voice quality (timbre) and rhythm, a listener can extract considerable information about a speaker's communicative intent.

Often the meaning conveyed via prosody is affective in nature indicating for example, happiness, sadness or anger. This is referred to as affective prosody. In addition to affect, prosody is also used to carry linguistic or pragmatic information, that allows a listener to discriminate among questions, statements and exclamation. This is known as linguistic prosody.

Regardless of function, the same three acoustic parameters serve as primary prosodic attributes : fundamental frequency (FO), duration and amplitude (Lehiste, 1970). Among the various components of prosody, intonation has been widely studied. Intonation is defined as the "Variation in FO as a function of time" (Crystal, 1981). It is the salt of an utterance, without which a statement can often be understood, but is tasteless and colourless (Delattre, 1966). Variations in intonation, is an important cue for identifying the

different sentence types, like declarative, interrogative etc. and also the emotion with which the sentence has been uttered.

Specific intonation patterns have been identified, for various sentence types and different emotions. For example, a declarative sentence has a falling intonation whereas, an interrogative sentence ends with a rise, in American English (Ladefoged, 1967). Studies in Indian language have also shown specific patterns like, in Kannada language, a statement used as request, shows a gradual rise followed by a gradual fall; an accusing statement has a steep rise followed by a steep fall (Nandini, 1985). Emotive sentences also show specific intonation curves. For example, in Kannada all emotional sentences are expressed with a final fall (Manjula, 1979); Anger has a steep rise - fall, surprise has a rise - steep fall contour etc. (Nandini, 1985). Though each language has some distinct patterns, some universal features are also seen across different languages (Nataraja, 1982; Nandini, 1985).

These intonation patterns are more dependent on the FO variation, than on intensity or other factors (Lado, 1961; Nandini, 1985). Hence the study of FO and its related measures are important when studying the intonation.

Unlike the other speech and language functions, speech prosody, especially affective prosody, has been found to be controlled by the right hemisphere (Tucker and Fredrick, 1989). Right hemisphere damaged (RHD) individuals, have been reported to perform poorly than left hemisphere

damaged (LHD) and non brain damaged (NBD) individuals in perception (Heilman, Bowers, Speedie and Coslett, 1984; Vanlancker and Sidtis, 1992; Starkstein, Federoff, Price, Leiguarda and Robinson, 1994; Geigenberger and Zeigler, 1998), production (Shapiro and Danly, 1985; Schulz, 1997) and in both perception and production (Ross, 1981; Mackenzie, Begg, Brady and Lees, 1997) of emotive intonation.

Besides studying the perception and production of affective tone, some researchers have tried to establish a functional - anatomical organization, in the right hemisphere, similar to that of the left hemisphere (Ross, 1981). He had described ten patients with right hemisphere damage, who could be classified, using nosology similar to the one used for language disorders following LHD. For example, 'motor aprosodia' for a patient with poor repetition skills but intact comprehension for speech prosody; 'sensory aprosodia' for one with normal expression, but disordered comprehension. The site of lesion also corresponded to their counterparts in the left hemisphere. But his findings were refuted by several researchers, as these results could not be duplicated in other studies (Danly and Shapiro, 1982; Basso, Lecours, Moraschini and Vanies, 1985).

Though other studies have also tried comparing anterior versus posterior site of lesion in RHD and the resulting production and perception deficits respectively (Weintraub, Mesulam and Kramer, 1981; Cooper Soares,

Nicol, Mechelow & Goloskie, 1984; Borod, Koff, Lorch and Nicholas, 1985), nothing conclusive could be established.

Acoustic analysis of the speech of RHD patients have generally reported of a restricted F0 range which gives the perceptual impression of monotony in voice (Ross, Edmondson, Seibert and Homan, 1988; Behrens, 1989; Pell, 1999). But not many studies have studied the features with respect to the lesion site or across various conditions like imitation versus reading task etc.

Hence, it is apparent that RHD as a group is still an enigma, when it comes to delineating their speech and language characteristics. The studies on prosodic features have failed to come to a definite conclusion. It is also seen that more research is required in the area of acoustic analysis of speech of RHD individuals, especially in affective intonation. Limited studies have been carried out in Indian languages on affective intonation in normals (Manjula 1979; Nandini, 1985;) and no study has been done in intonation, on a RHD population. Also there are a very few studies which have addressed the effects of imitation versus reading (Baum and Pell, 1999) and the type of sentence (semanticaliy loaded versus semantically neutral) on the intonation contours (Blonder, Bowers and Heilman, 1991).

Therefore, this study was taken up as an attempt to contribute towards and add on to the observation on the speech behaviour, specifically prosody of individuals with RHD, in an Indian language, Kannada.

AIM

The aim of the present study was to

> study the perception and production of emotive intonation in RHD individuals, with focal lesion in anterior and posterior regions of right cortex,
> across semantically loaded and semantically neutral sentences in Kannada,
> in both imitation and reading task.
> perceptually and acoustically.

METHODOLOGY

Three RHD individuals (two with posterior lesion and one with anterior lesion) and their age and gender matched control subjects, were asked to perceptually evaluate ten model utterances of Kannada language, depicting four emotions: anger, joy, fear and grief. They were also asked to imitate these sentences. Two types of sentences; semantically loaded and semantically neutral, were selected and two test conditions; imitation and reading task, was also considered. The utterances of these individuals, were subjected to both perceptual and acoustical analysis. Three judges were selected for the perceptual analysis. Acoustical analysis was carried out after obtaining the speech wave form, F0 and intensity curve, for all the utterances,

using the speech analysis software program (VAGHMI), of the voice and speech systems (VSS). The following F0 parameters were studied -

1. F0 of the primary stressed syllable.
2. (a) Maximum and Minimum F0
   (b) Range of F0
3. Variations in F0(contour)
4. F0 of initial and final syllable
5. Declination of F0.

LIMITATIONS

> Due to time restriction and non-availability of RHD patients, only three RHD subjects were taken up for the study.

> Since there were unequal number of subjects with anterior and posterior lesion, comparison across lesion site, and inferential generality of the results becomes restricted.

> Severity and extent of the lesion in RHD was not controlled.

REVIEW OF LITERATURE

Speech is a unique dynamic motor activity through which we express our thoughts, emotions, respond to and control our environment (Duffy, 1995).

Speech can be divided into segmentals and suprasegmental components. The suprasegmentals are also called as prosodic features and can be described by physical quantities of amptitude, duration and fundamental frequency (FO) of voice. These suprasegmental features include stress, intonation, rhythm and quality.

Prosody has been viewed as a decorative ornamentation, functioning to make speech more aesthetically pleasing. It is intrinsic and critical in both perception and production of speech (Freeman, 1983). He also suggested that prosody may serve as the interface between low level segmental information and higher levels of grammatical structure in speech. Investigations have provided evidence that prosodic information cuts across most, if not all, levels of perceptual analysis, influencing segmental analysis (Martin, 1979) and syntactic analysis (Liberman, 1967; Bolinger, 1972; Cooper and Sorenson, 1981). Perceptually, intonation assists the listener in segmenting the flow of speech by contouring words, and syntactically they help differentiate among the different sentence type such as declaratives, questions etc. The acoustic cues for prosodic features which have received the most extensive attention

are F0, intensity and temporal spacing of acoustic events (duration and rate measurements).

Monrad-Krohn (1947) distinguished four types of prosody -

(1) Intrinsic prosody - It refers to the intonation contour that distinguishes a declarative from an interrogative.

(2) Intellectual prosody - It refers to the placement of stress which gives a sentence its particular meaning.

(3) Emotional prosody - It conveys the various emotions like joy, anger etc., through specific intonation pattern.

(4) Inarticulate prosody - It consists of grunts or sighs and conveys approval or hesitation.

INTONATION

One of the widely studied prosodic feature is intonation. It is defined as the fluctuation of the voice pitch, as applied to the whole sentence. It is the sentence melody that is superimposed on the sentence as a whole (Freeman, 1983).

It must be differentiated from the 'tone' of the tonal languages. 'Tone' refers to a feature of a single syllable in a sequence. Intonation on the other hand, denotes a sequence of tones where function relates to a sentence or part of a sentence. The physical correlate of the intonation contour is the F0

of the excitation source, as a function of time. It is the change in F0 which is important rather than absolute values, as the fundamentals of men, women and children cover different frequency ranges.

Intonation has the following communication roles -

(a) It can be used to convey attitudes such as warning, boredom, surprise and neutrality (Crystal, 1981).

(b) Brazil, Coulthard, and Johns (1980) claim that speakers use intonation to signal whether the information is new or old.

(c) Intonation also has a grammatical function (Hargrove and McGarr, 1994). The normal terminal intonation pattern in a simple declarative and imperative sentence, in English, is falling. On the other hand, Yes-No questions have terminal intonation that rise.

(d) Intonation provides information about discourse and about a speakers attitude (Brazil et al., 1980). As Borden and Harris (1980) conclusively putforth "we know how a persons feels as often by how he says his message, than by the message itself".

In American English, the contours with the strongest meanings tend to occur at the end of the sentence, such contours are called as primary types. The stressed syllable constitutes the beginning point of every primary contour (Pike, 1945). Immediately preceeding the stressed syllable of a primary contour, there will be usually one or more syllables which are pronounced with

the same bursts of speed as that of a primary. These are called as pre contours.

Bolinger (1972) quotes three features of intonation, which have similar cues in all language.

> Range - It conveys emotion, eg. when one gets excited, the voice extends its pitch upwards.

> Direction - This is usually connected with pause. In most of the utterances, the pitch at the beginning of a sentence is high and then drifts down to the lowest pitch at the end. In some interrogative sentences, the direction often tends to be up all the way.

> Relative height - It is associated with the importance given to a particular word, or words in a sentence.

Within intonation, the linguistic features of intonation are determined by factors like fundamental frequency (FO), intensity and duration. The intonational differences that are heard as high or low, rising or falling, are primarily related to the frequency of sound waves (Lado, 1961).

The pitch variations in the intonation of a language constitute a system of distinctive units and patterns. It is found that English intonation has four distinctive pitch units, i.e., low, mid, high and extreme high. These are represented with Arabic numbers above the line of print (She^{2} has^{1} -) (Lado,

1961; Kurath, 1971 and Bolinger, 1972). The absolute pitch of these units varies for different occasions or in different parts of the same conversation.

Although variation in F0 is basic for various intonation contours (Pike, 1945; Lado, 1961), Denes (1959) showed that it was not always true and other acoustic characteristics like intensity, duration and spectrum may also serve as cues for the recognition of intonation. He substantiated this view by citing whispered speech, where there is no vocal fold vibration, but still the speech is able to convey the information. Liberman and Michaels (1962), supported Dene's (1959) view and conducted an experiment to show that although FO plays an important role in conveying intonation information, other features like amplitude also play a role. They asked three male native American English speakers to read eight neutral sentences in various emotional moods like question, statement, fearful utterance, happy utterance etc. Pitch pulses were derived from these utterances and were subjected to perturbation, rapid variation and amplitude modulation. These processed sentences were played to listeners who were asked to categorize the sentences into different emotions, in a forced choice task. Results revealed that unprocessed speech could be identified correctly 85% of the time. When only pitch information was presented, correct identification reduced to 44% and when only amplitude information was provided it further decreased to 14%. When amplitude information was added to pitch information the scores improved to 47%, thus showing that the role of amplitude information is also important in conveying appropriate intonation.

Ross and Duffy (1973) studied the portion of the frequency curve, which contained sufficient prosodic features for listeners to correctly identify the intended emotions of speakers. Nine different emotions in nine different paragraphs were presented under five listening condition viz. unfiltered, 600 Hz, 450 Hz, 300 Hz and 150 Hz low pass filtered (LPF) speech. Results showed that the intended emotion of a speaker could be well identified when perception task consisted of only the lower audible frequencies of speech.

Intonation has also been classified into linguistic and affective intonation, the former coding for the sentence types like declarative, interrogative etc. and the latter responsible for conveying the various emotions of the speaker like anger, joy, grief etc.

Linguistic intonation marks the different sentence types. For example, a declarative sentence has a falling intonation, whereas an interrogative sentence ends with a rise in American English (Ladefoged, 1967). In British English also, a falling pitch marks a declarative and Wh- questions. But in American English, questions not beginning with an interrogative are marked by a sharply rising intonation (Jones, 1964).

Nandini (1985) studied some linguistic prosodic aspects in Kannada language. She reported the following types of intonation associated with different sentence types as markers:

1) Rise-fall contour ——————————> Neutral statements

2) Rise-fall rise contour ——————————> Angry statements

3) Gradual rise followed by a gradual fall ——————————> Statements used on requests

4) Steep rise followed by steep fall ——————————> Accusing statements

Affective intonation is also defined as those global aspects of intonation, which deals with the attitudinal meaning of intonation (Fry, 1968). Williams and Stevens (1972) studied the gross acoustic attributes associated with various emotions. Their observations are tabulated below.

Emotions	F0 Range	Peak F0	Duration	Consonant production	Other features
1)NEUTRAL	—	—	Shorter than emotional situation	Imprecise for unstressed syllables	Little noise and irregularities
2) SORROW	Reduced	Less than neutral	Long	—	Voicing irregularities, Occasional noise, decreased rate of articulation
3) ANGER	Greater than neutral	High	Long	Precise	Voicing irregularities
4) FEAR	—	Less than anger	Longer than anger	Precise articulation	Voicing irregularities

Based on the above findings, the authors concluded that F0 contour versus time provides the clearest indication of the emotional state of the talker. F0 contour has a prototype shape for a breath group that is generated in a normal manner. Without marked emotion of any kind, normal contour is characterised by a smooth, slow and continuous change in F0 as a function of time. Different emotions affect this basic contour shape differently.

In one of the old Indian studies, Deva (1957) made analytical observation of affective intonation in speech of three Telugu speakers. They were asked to simulate the emotions of sorrow, anger and fear. From F0 measurements, he concluded that degree of emotion is correlated with raise in the frequency. Sorrow showed the least change, followed by anger and then fear. The extent and gradient of frequency rise was positively correlated with the degree of emotion but number of inflection in frequency curve was negatively correlated with it.

Rathna, Nataraja and Samuel (1976) studied identification of intonation with reference to context. They concluded that the listeners were not able to identify the correct pairs of intonation sentence and context sentence. They also found that it is possible to use similar kind of intonation pattern in different contexts in Kannada language. Thus, the reference context may become important in identifying the intonation. Similar to these observations, Ladefoged (1967) and Gunter (1975) also stressed upon the importance of context in intonation perception.

Manjula (1979) studied emotional intonation in Kannada language. She concluded that the emotional sentences in Kannada are expressed with a final fall in the intonation pattern. Contradicting this, Nataraja (1982) in his study of affective intonation, in four Indian languages of Kannada, Tamil, Gujarati and Hindi, under five emotional conditions of anger, joy, jealousy, mercy and neutral condition, reported that same intonation contour may be used to

express different emotional condition. Further he also concluded that same pattern or contours are seen across the different languages used. Hence there seems to be a common or universal intonation contour across the different languages studied.

Nandini (1985) studied some affective prosodic aspects in Kannada and found that there are different intonation curves for different types of emotion. She reported that for anger - a Rise (R) (Steep) -Fall (F) level(L) pattern, for surprise R-F (steep), jealousy R-F, Frustration R-F (slight) and accusing R (steep) - F (steep) patterns were observed in instrumental analysis. These correlated with the perceptual judgement also. She concluded that different intonation patterns are used by speakers to express different emotions and intonation pattems seem to depend more upon the FO variation than on intensity or other factors. She also concluded that the same kind of intonation patterns may be used to express different types of sentences. This is in agreement with observations made by Rathna et al. (1976), Manjula (1979) and Nataraja (1982).

HEMISPHERIC CONTROL ON EMOTIONS AND INTONATION

The cerebral cortex has been shown to play a role in several aspects of emotional function, like the cognitive ability to perceive, comprehend and express emotion, through tone of voice, gesture or facial expression. Right hemisphere has been reported to play a major role in the ability to interpret and express emotional information (Tucker and Fredrick, 1989). The emotional

information may be conveyed in the form of a facial expression, tone of voice (non-verbal) or verbally through speech.

Patients with right hemisphere damage (RHD) perform poorly than patients with left hemisphere damage (LHD) (a) when trying to discriminate between emotional faces and when attempting to name emotional scenes (De Kosky, Heilman, Bowers and Valenstein, 1980), (b) when matching emotional expressions (Cicone, Wapner and Gardner, 1980), and (c) when grouping both pictorically presented and written emotional scenes and faces (Etcoff, 1984). Patients with RHD are also impaired in the comprehension and appreciation of humorous or affective aspects of cartoons, films and stories (Gardner, King, Flamm and Silverman, 1975; Wapner, Hamby and Gardener, 1981; Lavanya, 1994). These studies provide evidence for lateralisation of emotions to the right hemisphere.

The left hemisphere also has some role to play in interpreting emotion. Bowers and her colleagues (1987), studied the abilities of RHD patients, to understand emotional information and reported that it depends upon a knowledge base that stores nonverbal information about the meaning of emotion, referred to as nonverbal affect lexicon. They contrast this ability with another type of emotional information processing, which is the ability to label emotions and to understand the link between certain situations and specific emotions, which they called as emotional semantics.

Hence, they contrast between the ability to comprehend the meaning of a facial expression, gesture or tone, which relies on the right hemisphere and the ability to know the reason for the expression. Whereas the nonverbal affect lexicon appears to be housed in the right hemisphere, the mechanisms that mediate emotional semantics seem to be located in the left hemisphere.

Intonation contours have also been reported to be lateralised to the right hemisphere. Blumstein and Cooper (1974) conducted two dichotic experiments to investigate the lateralisation of intonation contours. In one experiment, intonation contours that had been filtered from real speech exemplars of four English sentence types, yielded a significant left ear advantage (LEA), when subjects were given a perceptual matching task. This LEA was maintained when subjects had to identify the same stimuli by their sentence types. In the second experiment, non-filtered versions of four intonation contours superimposed on a nonsense syllable medium, as well as their filtered equivalents, were presented for a matching task. For both sets of stimuli, a LEA was obtained. Thus, neither the requirements of a linguistic response nor the presence of a phonetic medium succeeded in altering the LEA obtained in the perceptual matching task. These results suggest that the right hemisphere is directly involved in perception of intonation contours and that normal language perception involves the active participation of both the cerebral hemispheres.

Shipley-Brown, Dingwall, Berlin, Yeni-Somshian and Gordon-Salani (1988) examined the laterality for affective and linguistic prosody, using dichotic listening paradigm. They tested thirty two subjects, who were required to mark the emotion conveyed by twelve target sentences and also the linguistic information from another twelve sentences. The sentences were presented dichotically that is, a sentence spoken with an angry tone to right ear and with happy tone to left ear. Results indicated that right ear errors were significantly more than left ear errors. Even though not significant, there were more left ear errors for linguistic intonation than affective intonation and overall less errors on affective then linguistic prosody, indicating superiority of RH in processing the prosodic elements of language than the left hemisphere.

PROSODIC PERCEPTION DEFICITS

Studies have found that RHD subjects are impaired relative to both non brain damage (NBD) and LHD subjects in prosodic discrimination, thus suggesting that they have deficits in making purely perceptual judgements about prosodic information. These deficits are particularly evident in identifying emotional prosody, though studies report of deficits in linguistic prosody as well.

Heilman, Bowers Speedie and Coslett (1984) studied the performance of RHD, LHD and NBD subjects on an identification task of emotional and non-emotional prosody. Sixty sentences were selected, which were filtered such that the semantic message was unintelligible although the prosody remained

intact. For the non-emotional set, three types of sentences were selected i.e. declarative, interrogative and imperative. For emotional set, four emotions - happy, anger, sad and indifferent tone were used. The stimulus was delivered through headphones and subjects were asked to respond verbally or point to the appropriate card which carried the punctuation marks and line drawings of face, with different emotions. The results indicated a significant difference between RHD, LHD, and NBD group. The RHD group showed decreased comprehension of emotional prosody relative to either LHD or NBD group. But, the RHD group did not differ significantly from LHDs in non-emotional prosody task, though both the groups performed poorly when compared to NBD subjects. These findings suggest that the two hemispheres mediate prosodic information differently. They also compared patients with predominantly anterior lesions with those with posterior lesion and reported no significant difference for either RHD and LHD groups across site of lesion, on both the tasks.

Another study was conducted by the same authors(Bowers, Coslett, Bauer, Speedie, and Heilman, 1987), in which they asked the RHD, LHD and NBD groups to identify the emotional prosody of a set of sentences when the (a) semantic content was congruent versus incongruent with the emotional prosody, and (b) when the speech was filtered versus unfiltered. This was to test whether the deficits in comprehension were due to processing or distraction. The result of the first experiment revealed significantly poor comprehension of emotional prosody in incongruent than congruent condition

in RHD when compared to LHD and NBD groups. Additional analysis revealed no significant effect for site of lesion. The second task revealed an overall poor performance of RHD than LHD and NBD and significantly poor comprehension of filtered speech than unfiltered speech, for emotional prosody. Hence, there results indicate both the presence of processing and distraction defects contributing to comprehension difficulties of emotional prosody in patients with RHD.

Supporting the above results, Blonder, Bowers and Heilman (1991), in their study, also found significantly poor performance of RHD patients when compared to LHD and NBD group, on perception tasks. They carried out three tasks - (1) judgement of emotional prosody and facial expression, (2) comprehension of verbal descriptions of non-verbal expression of emotion. Eg. "he scowled" and (3) comprehension of emotional sentences. Results revealed that RHD patients were significantly impaired in first two tasks when compared to LHD and NBD, but comparable to them in the third task.

These findings support two competing interpretation regarding the role of right hemisphere in emotional communication. These authors have suggested that there may be two independent systems that are impaired following RHD - one for decoding the complex auditory and visual patterns present in non-verbal emotional expression and another which associates non-verbal behaviour with emotions. A second hypothesis put forth was that a hierarchical system mediates the comprehension of non-verbal communication

stimuli. The base of this system may be formed by the direct facial and prosodic input. Moving up one level in the hierarchy, the right hemisphere may house category specific lexical semantic representation of nonverbal expressions, and RHD either destroys or prevents them from being activated. Hence, the ability to comprehend the meaning of verbal descriptors of nonverbal expressions may also require the formation and interpretation of a mental image of these expression, which may be disrupted in RHD.

In a study by VanLancker and Sidtis (1992) twenty four LHD, thirteen RHD and thirty seven NBD subjects, were required to match affective prosodic speech utterances with appropriate facial expression. The test sentences were also acoustically analysed to find what cues were used by the three groups for perception. Both LHD and RHD performed comparably on the affective and linguistic tasks and both groups did poorly than the control (NBD) group. Although RHD group performed better than LHD on the linguistic task, it was not statistically significant. In affective task, the RHD group tended to label negative emotions as positive more than the LHD group. The results of acoustic analysis indicated that F0 variability was the major cue in distinguishing between affective categories in this stimulus set. But RHD patients did not make use of F0 variability and relied on duration cues to make their affective judgements. In contrast, LHD group did make use of FO information, but performed poorly nonetheless.

Borod, Andelman, Obler, Tweedy and Welkowitz (1992) studied the contribution of lexical/verbal channel to emotional processing in sixteen RHDs, sixteen LHDs and sixteen NBD adults. Emotional lexical perception task and an analogous non-emotional tasks were developed, which included word identification, sentence identification and word discrimination. For both these word tasks, RHDs were significantly more impaired than LHDs and NBDs, in the emotional condition. For all the three tasks, RHDs showed a significantly greater performance discrepancy between emotional and non-emotional condition, than LHDs or NBDs. Results were not affected by the valance (positive/negative) of the stimuli. There findings suggest a dominant role for the right hemisphere in the perception of lexically based emotional stimuli.

Results of fifty nine stroke patients, in comprehension of emotional prosody tasks was also correlated with the neuropsychological and neuroradiologic reports (Starkstein, Federoff, Price, Leiguarda and Robinson, 1994). The comprehension task included identification of tone of thirteen sentences, which were uttered with either happy, sad or angry tone. The response was pointing to the appropriate line drawing of such faces with the emotions typed underneath. Another task required them to identify sixteen sentences, where the semantic content and the tone were reversed. Patients were classified into the aprosody and non aprosody groups, based on their performances on both the task. Nineteen patients who failed on both the task were included in severe aprosody group, ten who failed on only one task in mild aprosody group and the rest in no-aprosody group. There was no effect

of type of emotion on aprosody score and also patients performed better with semantic cues in agreement with the tone, than otherwise.

Results of correlation with other tests showed that comprehension deficits were not necessarily associated with post stroke depression and also that patients in aprosody groups showed a higher frequency of right hemisphere lesion.

Schmitt, Hartje and Willmes (1997) investigated the effects of unimodal and simultaneous multimodal stimulation on recognition of emotional attitude, in twenty seven RHDs, twenty five LHDs and twenty six NBDs. All subjects were shown 330 videotaped items of four second duration each, which was to be judged in terms of facial expression, emotional prosody and emotional meaning of the underlying spoken sentences. RHDs performed significantly worse than both LHDs and NBDs in unimodal stimulation. RHD group showed a significantly poor performance for facial expression and prosody than the other two groups. In the text modality, there was a significant difference between LHDs and NBDs.

With simultaneous multimodal stimulation, a consistent group difference was observed. RHDs showed a significant better recognition of text compared to prosody, than both LHDs and NBDs. On the whole, RHDs performed poorer in processing emotional information in facial expression and prosody, when compared to NBDs. Conversely LHDs perfosrmed significantly poorer

on the task of discerning emotion out of propositional sentence meanings, which was apparent in multimodal task only.

A recent study to test the localization of emotional processing in normals and brain damaged was conducted by Geigenberger and Ziegler (1998). They studied the comprehension of emotional prosodic information from twelve test sentences, carrying different emotion - anger, fear, sadness, happiness, tenderness and desire. They also studied comprehension of facial expression to evaluate the dissociation between different communication channels. Results revealed a considerable deviation of the RHD group from the normals and a high intra and inter subject variance on most of the test items. LHD group showed less variations for both the tasks and also showed less deviation from the normal group. On the whole, RHD group differed significantly from LHD and normal group for the prosody task and to a lesser extent on the facial expression task. Comprehension of linguistic prosody was also tested and it was seen that normals made no errors, while both the patient group were impaired, LHDs being significantly worse than RHD patients.

PROSODIC PRODUCTION DEFICITS

The flat, robotic, monotonous prosodic production of RHD patients has been quoted often in literature. Other prosodic deficits reported are problems in matching prosodic contour to emotional content, reduced reliance on pitch variation to signal emotions and increased reliance on semantic information,

rather than prosody, to convey emotions (Myers, 1999). Clinically, these problems are evident in both emotional and non-emotional conversational contexts. Experimentally however, these problems have been found to be more pronounced in emotional communication.

Shapiro and Danly (1985) made an attempt to correlate deficits in speech prosody across emotional and non-emotional domains, with certain lesion sites in the right hemisphere. Patients with right anterior, right central, right posterior and left posterior, unilateral brain damage, were tested. They were required to read 4 sets of sentences, each set containing four paragraphs, each containing a target sentence that was either declarative, interrogative, happy or sad. The semantics of the target sentence alone was affectively neutral in two sets, whereas it was loaded or the sentences cued happy or sad emotion in the other two sets. The following results were obtained:

- A highest mean F0 value for the right posterior and lowest value for right central patients. Patients with left posterior produced much lower F0 values and those with anterior much higher than expected.

- Right posterior brain damaged displayed greater F0 variability and a greater F0 range than NBD and left posterior patients. Right central and anterior groups showed reduced F0 variability and a restricted range.

- In the interrogative sentences (Yes-No type), NBD and left posterior group produced an average rise in F0, right posterior group produced a larger F0 rise, while right anterior and central groups produced a greatly attenuated F0 rise.

- NBD and patients with right posterior and left posterior lesion could signal either happy or sad sentences through F0 modulation, while patients with right anterior or right central damage were quite limited in their ability to use F0, to signal these emotions. Also, right posterior, NBD and left posterior groups tended to signal the happy or sad distinction using variability in F0 in a greater degree, in semantically neutral target sentences, while ones with right anterior and central, did so more in semantically loaded sentences.

Thus, this study supports the conclusions of Weintraub Mesulam and Kramer (1981), Cooper et al., (1984), and Danly and Shapiro (1982), that the prosodic deficits observed in patients with RHD may not be specifically related to an affective content. These studies have shown several disturbances in speech prosody in RHD in non affective contexts also. The result of this study further indicates a marked difference in speech prosody between patients with damage to anterior and posterior region. The damaged anterior portions of the right hemisphere displays flat speech across both emotional and non-emotional domains, whereas those with damage to the posterior regions appear hypermelodic in their contents.

Borod, Koff, Lorch and Nicholas (1985) studied the contribution of facial, intonation and speech channels to spontaneous emotional expression in twelve RHDs, fifteen LHDs and sixteen NBD subjects. The patients were tested at least one month after the onset of illness and were also divided into anterior or frontal lesion and posterior or non-frontal lesions, based on the lesion site. Subjects were videotaped while viewing and responding to a series of emotionally laden slides. The videotapes were then rated for the three channels of communication. Overall, the RHDs used facial expression and intonation less frequently than the other two groups. Also, those with right frontal damage used facial expression significantly less than each of the other two groups, while those with left frontal damage used the speech channel less frequently than the other two groups. Those with right non-frontal and frontal used intonation channel less frequently than those with left frontal and non-frontal damage.

Analysis of speech output revealed that the speech of RHDs was judged to be more propositional and more descriptive than that of the LHDs and NBDs. There was no significant difference between anterior and posterior damage in this respect. These findings are compatible with the notion that the right hemisphere has a predominant role in the expression of emotion.

Schulz (1997), reviewed the recent literature on the type of speech production impairments, following damage to the left and right cerebral hemispheres. Damage to the left anterior language areas causes primarily a

phonetic impairment that is, a deficit in executing the articulatory maneuvers of sound production, with a preserved ability to select the correct sound. Damage to the left posterior language areas causes a phonological impairment, while damage to the right hemisphere causes a speech production problem the prosodic aspects of language. She has discussed the direct implication of these findings on the therapeutic remediation.

Baum and Pell (1997) tested the functional lateralization hypothesis of speech prosody in RHD, LHD and NBD in linguistic and affective prosodic tasks, at sentence level. The different tasks carried out were repetition versus reading, varying the amount of linguistic structure by filtering the speech stimuli, using nonsensical and semantically well formed stimuli. In general, the results demonstrated that both RHD and LHD patients were able to appropriately utilize the acoustic parameters (duration, F0, amplitude) to differentiate both linguistic and affective sentences types, in a manner comparable to NBD subjects. Some irregularities in global modulation of F0 and amplitude by RHD speakers were noted. Overall, the present findings do not provide support for previous claims that right hemisphere is specifically engaged in the production of affective prosody.

PROSODIC DEFICITS IN PERCEPTION AND PRODUCTION

Several studies have discussed both the perception and production abilities in RHD patients.

Tucker, Watson and Heilman (1977) examined eleven RHDs with parietal lobe lesion, seven LHDs with conduction aphasia and eight patients with intracranial disease. In one experiment RHD and LHD groups were tested For comprehension and discrimination of affective speech in sixteen sentences depicting either anger, joy, grief or indifference. In another experiment, RHD and intracranial disease patients were tested in their abilities to evoke emotionally toned sentences. The results indicated that patients with right temporo-parietal lesions have deficits in both comprehension and evocation of affective tones.

Some investigations report of more global prosodic deficits in patients with RHD and not restricted to emotional prosody. Weintraub, Mesulam and Kramer (1981) tested discrimination, repetition and spontaneous production of non-emotional prosody in nine RHD patients and eleven normal control subjects. They reported that RHD patients performed significantly worse than normal control subjects, in their abilities to distinguish and express prosodic features that provide phonemic or emphatic information. These results suggest that RHD may affect prosody in a more general manner than was previously assumed.

Ross and Mesulam (1979) were instrumental in attracting attention of clinicians to the systematic study of RHD patients. They reported a case study of RHD with a weak, monotonous voice. She was unable to adequately express here emotions though she affirmed that she understood the meaning of the intonation and gestures of the family. She had spontaneous recovered and regained a normal intonation pattern. Ross and Mesulam (1979) termed this inability to modulate emotional prosody as "aprosodia".

Ross (1981) provided evidence for the right hemisphere processing of prosody, stating that it was a mirror image of the areas in left hemisphere identified for language. He assessed the RHD patients on quality of intonation in responses to questions, repetition tasks and in comprehension of prosody. He also provided an anatomo-ciinical description for each of the ten cases, using a nosology similar to the one used for language disorders. He classified three patients as presenting 'motor aprosodia'. One patient was labeled as global, two as transcortical motor, one as transcortical sensory, one as mixed transcortical and one with motor aprosodia with pure prosodic deafness. Ross (1981) concluded that the language contribution by the right hemisphere seems to be anatomically and functionally organized along two liners of prepositional language in the left hemisphere.

Gorelick and Ross (1987) followed up this study in fourteen RHD patients in order to further define the clinical anatomical correlates of aprosodias. They were examined on four tasks - (1) spontaneous affective

prosody and gesturing, (2) affective prosodic repetition, (3) affective prosodic comprehension, and (4) comprehension of emotional gesturing. Like in the previous study, they could classify the cases into subtypes of aprosodias, based on correlation between the affective prosodic tasks and CT scan reports. In this study, they reported two more subtypes of aprosodia; conduction and pure affective deafness, which had not been reported previously.

These findings were refuted by several researchers (Danly and Shapiro, 1982; Basso et al., 1985; Schalenger, Schalenger and Gertsmann, 1976) as there was (a) lack of validation of the examination protocol, (b) only one judge was involved, (c) a parallel with the anatomo-clinical classification of aphasia itself is a source of debate and has no theoretical justification, (d) prosodic disorders are most frequent during the initial few days and are unstable, hence suggesting that reactional emotions could be involved in such cases, and (e) the assertion that there are no negative cases is unjustified, as disorders of comprehension of emotional prosody have also been described in aphasics.

Cancelliere and Kertez (1990) investigated the relationship between intrahemispheric location of lesion and disturbances of emotional expression and comprehension in RHD, LHD and NBD subjects. The results revealed that symptoms of impaired comprehension of facial expression and depiction of emotional situation, were most frequently associated with basal ganglia

lesion. In some cases, anterior temporal lobe, insula and perisylvian region of right hemisphere were also involved. In majority of cases, lesion localization in RHD patients with specific aprosodic syndrome, did not support Ross's (1981) anterior - posterior emotional prosody circuit. Some patients with aprosidia had lesion compared to those region of cortex, not generally involved in mediation of expression and comprehension. This finding was seen only in RHD patients and suggested a more diffuse representation of emotional expression and comprehension in the right hemisphere. Another possibility is that these patients were suffering from confusion or an attentional disturbance which interfered with their performance.

Mackenzie, Begg, Brady and Lees (1997) also reported RHD patients to be weaker in several aspects of spoken language comprehension, particularly metaphor and inference. In conversation also, they used limited facial expression, eye contact and monotonous intonation. But other discourse parameters like verbosity and topic maintenance did not differ among the groups.

ACOUSTIC ANALYSIS OF INTONATION IN RHD

Ryalls, Joanette and Feldman (1987) tested RHD and NBD subjects for imitation of five non-emotional sentences after the investigator. The output was acoustically analysed for average F0, range of F0, adjusted F0 range, slope of F0 declination and overall sentence duration. No significant difference was Found between RHD Vs NBD, RHD with anterior lesion Vs

those with posterior lesion and early post onset (<100 days) Vs late post onset (>100 days). This finding questioned the hypothesis of functional lateralisation for non-affective prosody as proposed by Ross (1981).

A within - subjects study of the affective characteristics of voice was carried out in RHD patients undergoing a WADA test by Ross, Edmondson Seibert and Horman (1988). All patients became densely aphasic after left sided WADA test and lost the ability to impart affect into speech after right sided WADA test. The effective changes in voice induced by the WADA test were acoustically analyzed by computer assisted techniques and compared to data obtained pre and post-WADA test. The statistical results using ANOVA confirmed the current view that the right hemisphere modulates the affective components of language.

Behrens (1989) characterized the sentence intonation of RHD patients, focusing on a greater number of acoustic parameter and relying on more naturally elicited speech samples through strong completion tasks. RHD and NBD subjects were asked to produce a declarative and imperative sentence as well as Yes-No and Wh- questions. Slope of F0 change, linearity of pitch contour and variance of F0 points were calculated for each utterance as a whole, as well as pre-terminal and terminal contour. Results indicated less linear and flatter F0 decline than normals for declarative sentences and smaller F0 dispersion around F0 for Yes-No questions. Pre-terminal range values were also more restricted For Yes-No question. These results suggest

some disturbance in the RHD patients ability to manipulate the across sentential domains. Also, it was seen that this dysprosody in expression reflected a primary deficit in vocal pitch modulation, independent of emotional or linguistic demands.

Another study was conducted to determine hemispheric specialisation in processing linguistic and non-linguistic intonation contours in LHD, RHD and NBD subjects by Perkins, Baran and Gandour (1996). The LHD group showed significantly poorer performance in linguistic based tasks, but no difference among the groups was reported for discrimination of segmentally identical sentences. RHD group performed poorly when the segmental information was degraded and they had to discriminate isolated prosodic structure. These findings support the Functionalist hypothesis of hemispheric lateralization, in that the left hemisphere was dominant in processing intonation contours that have linguistic function, while the right hemisphere was dominant where the linguistic significance was reduced.

To study the nature of right hemisphere's involvement in expressive prosodic functions, a story completion task was administered to RHD and NBD subjects by Pell (1999) and utterances modality and emotional tones were elicited from both the groups. The output was subjected to acoustic analysis to examine various F0 attributes - mean F0, pitch accent F0 variation. Results indicated that the RHD group tended to produce F0 patterns that resembled normal productions in overall shape, but with significantly less F0 variation. In

perceptual analysis also, the RHD group was found to be less reliable than normal speakers in transmitting emphasis or emotional contrasts.

From the review of the studies on perception and production of affective prosody in RHD, we can find an agreement on the superior role of right hemisphere in processing affective prosody, though nothing conclusive can be said about the functional lateralization within the right hemisphere. Though Ross (1981, 1987) did make an attempt to give a detailed description of anatomic functional regions in the right hemisphere, it has been refuted by some. Disorders of affective prosody have been described in LHD also (Schalenger et al., 1976) and role of subcortical structures in perception of affect has also been defined (Cancillere, 1990).

Besides this, few studies have acoustically analyzed the expressive speech of RHD patients in terms of intonation contours. Most of these studies have only analysed in terms of F0 range and F0 variation in the utterance. But not many have conducted these analysis with respect to localised lesions, in terms of posterior Vs anterior region. Some of them have hypothesized the possibility of finding better perception for affective intonation by RHD with anterior lesion and better production of affective intonation by RHD with posterior lesion. Present study has addressed this issue.

The aims of the study were :

> perception and production of emotive intonation

> in normal individuals and RHD patients with focal anterior and posterior lesion,

> across sentences carrying emotive intonation which are semantically loaded and which are semantically neutral.

Need For the study - It arises from the observation that -

> Very few studies have studied the perception and production of emotive intonation patterns, in specific lesion sites in RHD.

> Studies have not addressed the effects of imitation Vs spontaneous production on intonation contours.

> There is still no agreement on the localisation of functions within the right hemisphere.

> No study has been done in Kannada language and the prosodic features vary with languages.

METHODOLOGY

The review of literature on perception and production of affective prosody in RHD, supports the superior role of right hemisphere in processing affective prosody, though nothing conclusive could be said about the distribution of language functions within the right hemisphere. Some studies have attempted to attribute certain functions to specific regions in the right hemisphere (Ross,1981,1987), others have refuted the same (Cancillere,1990; Schalenger et al., 1976). Not many studies , on acoustic analysis of the speech of RHD have been done with respect to the site of lesion, that is , anterior versus posterior. The present study was hence conducted to address these issues.

OBJECTIVES

The aims of the study were:

(1) To study the perception of emotive intonation in RHD individuals, with focal lesion in the anterior and posterior regions of the right cortex, across semantically neutral and loaded sentences.

(2) To study the production of emotive intonation in the same RHD individuals, across semantically neutral and semantically loaded sentences, in both imitation and reading task.

(3) To perceptually analyse the productions of both the groups, in their abilities to produce the appropriate affect in their speech.

(4) To acoustically analyse the intonation features in the utterances of these individuals.

HYPOTHESIS

(1) There is no difference between perception and production of emotive intonation in subjects with RHD.

(2) There is no difference in the perception of emotive intonation, in RHD individuals and normal controls.

(3) There is no difference in production of emotive intonation in RHD individuals and normal controls, in both imitation and reading task.

(4) There is no difference in perception and production of emotive intonation, across semantically neutral versus semantically loaded sentences.

SUBJECTS

The experimental group comprised of three RHD individuals; two with posterior lesion and one with anterior lesion. Two control subjects (one matched with two RHDs, who were of the same age) were selected, who matched the experimental group with respect to age and gender. The control subjects had no history of any neurological deficit, speech- language and hearing disorder.

CRITERIA FOR SELECTION OF SUBJECTS

Experimental Group -

(i) RHD adults without gross comprehension and expression problems, were selected, based on Western Aphasic battery, to rule out the

involvement of the left hemisphere. Though a standardized right hemisphere battery is available in Kannada language, it does not tap the prosodic features selected for the study, and hence was not considered.

(ii) The etiology underlying RHD was stroke following cerebro vascular accident (CVA), restricted to the right hemisphere, with a post onset period of atleast one month.

(iii) The information about the neurological lesion was obtained from the diagnostic report of neurological evaluation and substantiated by reports of CT scan. This data was used to classify them into anterior and posterior RHD.

(iv) The subjects were all right handed, pre and post morbid.

(v) They were all native Kannada speakers, who spoke the same dialect of Kannada.

Control group -

(i) Normal individuals who were age and gender matched with that of RHD subjects were selected.

(ii) There was no history of neurological, psychological, speech-language and hearing deficit, as per the screening tests administered for these abilities.

(iii) Only right handed individuals who were native speakers of Kannada language, were selected.

Table 1 : Demographic and medical data of the subjects

Subject	Experimental Group					Control Group	
	Age	Sex	Site of Lesion (CT Scan Report)	Etiology	Post onset period	Age	Sex
1	52yrs	M	Right Temporo-parietal area, Basal ganglia, internal capsule	CVA	1 Mo.	52yrs	M
2	62yrs	M	Right Frontal Cortex, head of right caudate nucleus	CVA	1 Mo.	62yrs	M
3	62yrs	M	Right High Parietal Region	CVA	1 Yr.		

EXPERIMENTAL DESIGN

It comprised of (a) selection of test material, (b) recording by a model speaker, (c) a pilot study to check the validity of selected sentences, (d) administration of perception and production tasks on RHD subjects and their normal counterparts and (e) perceptual and acoustic analysis of the recorded data.

STEP-I

SELECTION OF TEST MATERIAL - Twenty semantically neutral and twenty semantically loaded sentences, in Kannada language, were selected. In both the categories, five sentences depicted each of the four emotions - anger, joy, grief and fear.

TYPE OF SENTENCES - The sentences were selected such that they included familiar words and context used by an average Kannada speaker, in everyday life. The sentences selected, formed a part of daily conversation.

SELECTION OF MODEL SPEAKER - A 'good speaker' was selected to serve as a model. A fluent female speaker of Kannada, was requested to utter the experimental sentences, simulating the appropriate emotions to be conveyed by the sentence. The speaker was a speech language pathologist, who had experience in dramatics and a working knowledge in the area of prosody.

STEP-II

INSTRUCTIONS TO THE SPEAKER BEFORE RECORDING

The speaker was blind to the purpose of the study. She was given a list of sentences and asked to utter them with a particular emotion. She was instructed to take as many trials as required, till she was satisfied with the recordings.

RECORDING OF TEST SENTENCES - All sentences were recorded on Ahuja Stereo Recorder (4040S), with a unidirectional microphone, in a quiet room.

PILOT STUDY - In order to check whether the model speaker has effectively expressed the intended emotions, a pilot study was carried out. The recorded sentences, were played to three judges, who were speech - language pathologist with a working knowledge in the field for a minimum of five years and, were native speakers of Kannada language.

INSTRUCTION TO THE JUDGES - They too were not informed about the objective of the study. They were asked to listen and indicate on the checklist provided by the experimenter, the intended emotion of the utterance. The checklist format is given in Appendix A.

The recorded sentences were played to each judge separately, without mutual consultation. They were asked to rate the sentences on a three-point rating scale on (3) - excellent, (2) - fair and (1) - poor. Only those sentences which were rated as (3) by at least two judges, were selected for the experiment. Ultimately, four sentences for each emotion, two each from - semantically neutral and loaded conditions, were selected, constituting a total of sixteen sentences (Appendix B). Four sentences, one for each emotion, were also selected as trial sentences and these were different from test sentences.

From the experimental sentences selected, three lists of eight sentences each, was made randomly. Each list had four semantically neutral and four semantically loaded sentences, such that each category had all the four emotions represented equally. Randomisation was done in such a way, that none of these three lists had all the sentences alike.

STEP-III

DATA COLLECTION - The experimental and control groups were given two tasks -

(i) Perception task

(ii) Production task

These two subtests were administered with a rest period between them. For each subtest, practice trials were given to the subjects, with a set of trial sentences which were different from the experimental sentences.

/ - *PERCEPTION TASK* - The subjects were instructed to listen to the pre-recorded stimuli, presented in an audio tape through speakers. Instructions to the subjects were:

"A set of sentences will be presented through speakers. You have to identify the emotion conveyed by each sentence, from a choice of four given in the checklist. We shall have a trial with four sentences initially. Have you understood ? Shall we start now ?"

During the trial sessions, four recorded trial sentences were presented which were different from the experimental sentences. The subjects were also given additional visual cues to make them understand the task completely.

Each subject was presented with a different set of sentences obtained by randomisation. The list presented to RHD individuals and their age

matched normals, were however the same. A checklist (Appendix A) similar to the one provided to the judges in the pilot study, was given to the subjects, to mark the emotions they perceived from the sentences.

Reliability check - Apart from the eight experimental sentences, two more from the same set, were repeated for each subject, in order to check for reliability of responses.

Scoring - Total number of correct responses was computed. In this way, the maximum score possible was 10 and minimum was 0.

// - *PRODUCTION TASK* - This task comprised of two subtests:

(a) Imitation of the sentences uttered by the model speaker.

(b) Reading the sentences with respective emotion.

(a) *Imitation task* - One of the sets of ten recorded sentences was played to each subject. Instructions to the subjects were:

" A set of ten sentences will be presented to you, through speakers. You will have to imitate the sentences you hear, in the same manner as it is said. Each sentence is said with a particular emotion. We shall first try with four sentences. If you have understood, we shall then proceed with the test."

The instructions were repeated and trials increased, if the subjects failed to imitate with the trial sentences, till the task was understood.

Recording - It was done using the same instrument, as for the recording of the test sentences.

(b) *Reading task* - In this task the stimuli was presented via graphic modality. The sentences to be uttered were written on cards, with the intended emotion written in brackets, next to the sentence. Instructions to the subjects were:

" You will be given a set of cards, with a sentence written on each of them. You will have to utter the sentence with appropriate emotions, as will be mentioned next to each sentence. We shall first have trials and then proceed further. Have you understood ?"

Recording - It was done as mentioned in the previous task.

STEP-IV

ANALYSIS - The subjects responses were analysed both perceptually and acoustically.

PERCEPTUAL ANALYSIS - The sentences imitated after the model and read with graphic cues, by the subjects, were played to the same three judges, who had participated in the pilot study. They were given the same checklist

(Appendix A) and were asked to identify the emotional tone conveyed by the utterances. They were also asked to rate the utterances in the same way as was done in the pilot study.

ACOUSTIC ANALYSIS - The utterances were also subjected to acoustic analysis. The aim was to analyse the intonation features in the sentences uttered by the subjects and look for differential features, if any in the :

- imitated versus reading sample
- semantically neutral versus semantically loaded sentences.

The utterances of RHD individuals were also compared against the normal group, to find the deviancy from normal, in terms of intonation contours.

The speech samples were digitized using the speech interface systems of Voice and Speech System (VSS), at a sampling rate of 16KHz, using the program 'Record' of VSS software. Digitized data was stored on the hard disk of the computer. The 'INTON' program of VAGHMI software package of VSS was used to extract the fundamental frequency, intensity and wave form readings of the sample. The extracted F0 and I0 for each utterance was stored on the hard disk of the computer and displayed on the computer screen. Printouts for F0 and I0 curves and waveform were obtained using a printer. Based on this the following F0 parameters were analysed :

(1) F0 of primary stressed syllable in the sentence.**

(2) (a) Maximum and minimum F0

(b) Range of F0

(3) Variations in F0 (Contour movement)

(4) F0 of initial and final syllable

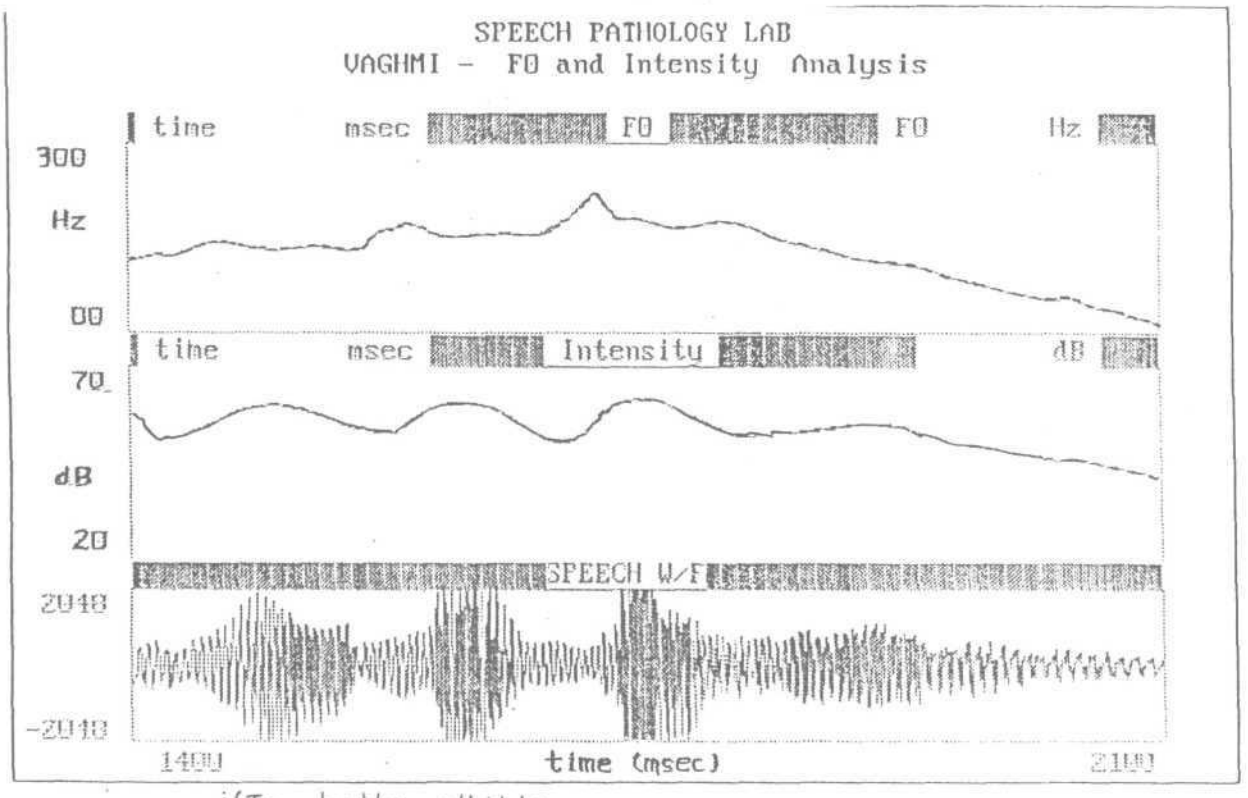
(5) Declination of FO

**The identification of the primary stress, in the sentence, was based on the perceptual judgements of the investigator and another qualified judge. Later the acoustic correlates of stress , that is , F0, intensity and duration were analysed.

STATISTICAL ANALYSIS

The raw data was subjected to appropriate descriptive and inferential analysis.

SAMPLE OF SPEECH WAVEFORM, INTENSITY AND FREQUENCY CONTOURS OF A POSTERIOR RHD SUBJECT, FOR AN ANGER UTTERANCE.



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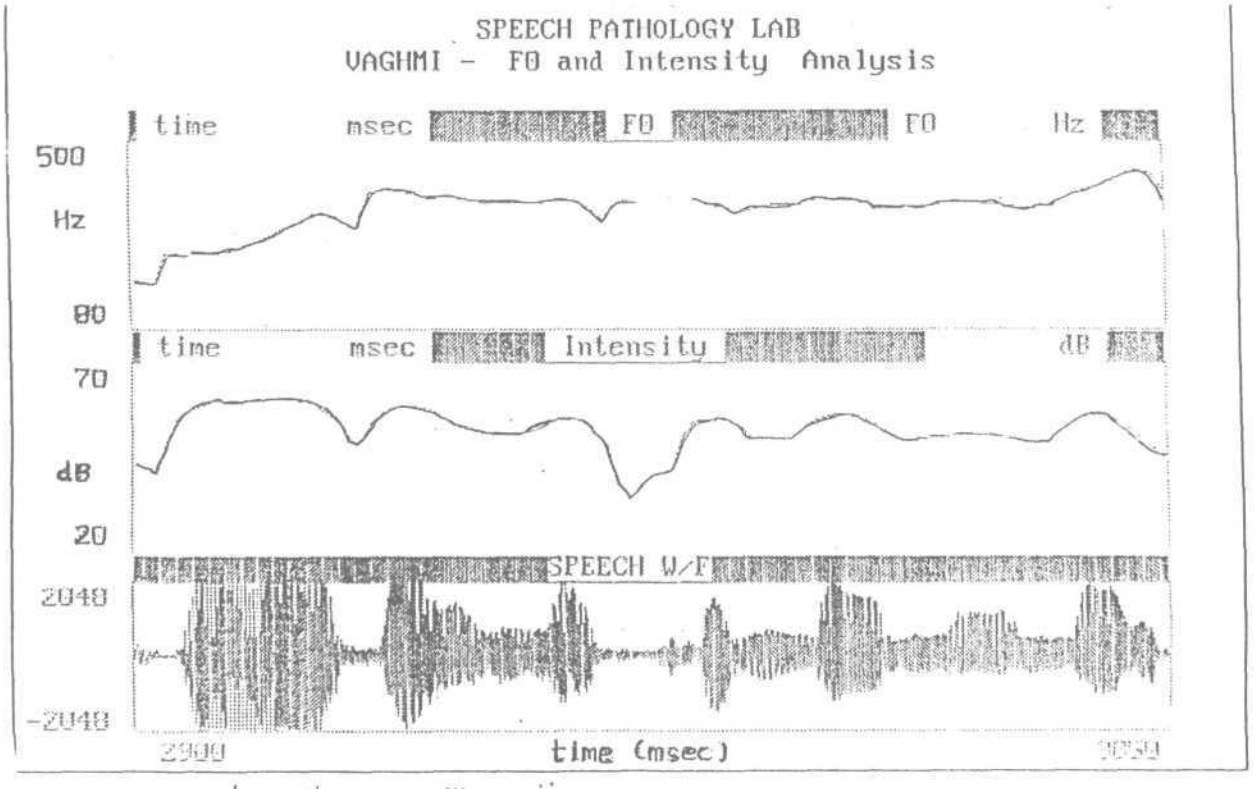
SAMPLE OF SPEECH WAVEFORM, INTENSITY AND FREQUENCY CONTOURS OF A NORMAL SUBJECT, FOR AN ANGER UTTERANCE.



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RESULTS AND DISCUSSION

The performance of the experimental and control subjects, on both perception and production task, is perceptually and acoustically analysed. A descriptive analysis pattern is adopted since the numbers of subjects are small. Statistically analysing the results would not have provided a true representation of each individual's performance. During interview and experimental phases with RHD subjects, it was observed that each subject has a unique speech and language characteristic. Even among the subjects with same site of lesion, there is a marked difference in intonation patterns used, which is evident during normal conversation and the experimental tasks. Hence it is felt that an individualistic descriptive analysis of the results, would be a true representation of the subjects under study.

Although the lesion site in the RHD subjects, was primarily in the right cortex, involvement of other sub cortical structures was also reported in their medical records. Hence the effect of a focal lesion in the right hemisphere should be considered within this limitation.

The results are discussed under the following domains -

(1) Perceptual analysis of subjects judgement of model utterances.

(2) Perceptual analysis of utterances of the subjects, by the judges.

(3) Acoustic analysis of the utterances of subjects, based on the following parameters:

> Primary stress
> Max. F0, Min. F0 and Range of F0
> Declination
> Initial syllable F0 (ISFO), Final syllable F0 (FSF0)s
> F0 contour of the utterances

I Perceptual analysis of subjects judgement of model utterances

The normal control and RHD subjects were asked to perceptually judge the emotions conveyed by the model speaker's utterances. They were provided with a score sheet (Appendix A), to record their responses.

The responses of the five subjects - two control and three RHD to the perception task, are given in the form of a matrix (Fig.1). It is depicting the scatter of the responses, from the expected responses.

> It is seen that the normal control group (N1 and N2) scored 100% correct responses in this task. Even among the RHD group, not much deviancy is observed.

Subject 1 - P1 (Posterior lesion), has one error in judgement, in identifying an anger utterance as one depicting fear. Though P1 had overall normal comprehension, he sometimes failed to follow the instructions and needed repetition.

Subject 2 - P2 (Posterior lesion), has maximum perception errors. Twice he has judged fear as an anger utterance, and once a grief

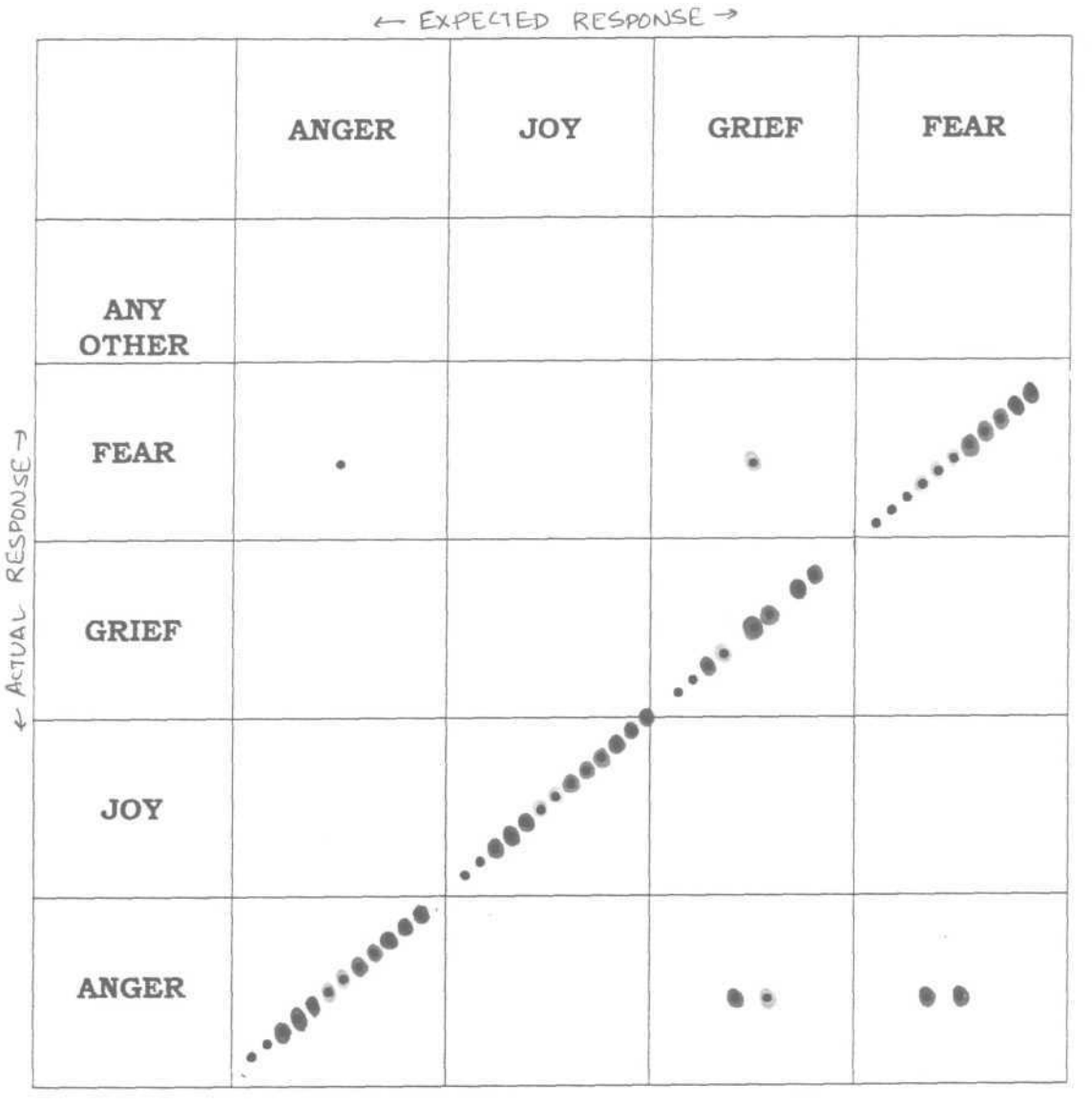


Fig.1 - Subjects perception of the model speaker's utterances

KEY :- P1 (POSTERIOR) -
P2 (POSTERIOR) -
A (ANTERIOR) -
N1 (NORMAL) -
N2 (NORMAL) -

sentence as anger again. P2, has some general comprehension deficits in general conversation also, along with deficits in identifying affective prosody. He needed more practice trials to understand the task.

Subject 3 - A (Anterior) also has two errors in judgement. Once he has identified grief as anger and again as a fearful utterance. But in general conversation, he did not appear to have difficulty in following instructions or understanding the task.

Literature reports of deficits in perception of affective prosody, in RHD patients (Heilman et al., 1984, 1987; Ross et al., 1988, Blonder et al., 1991; Geigenberger and Zeigler, 1998) when compared to LHD and normals. In the present study also, though not significant, RHD group performed poorly than normal control subjects.

> When analysed across emotions, grief is observed to be perceived erroneously most often (three times), followed by fear (twice) and then anger (once). Grief, is an emotion, which has the most limited F0 variation (reduced range) and hence not represented strongly by acoustical variations (Williams and Stevens, 1979). Context would play a more important role in identifying grief.

Fear, has acoustical attributes, quite similar to those of anger (Williams and Stevens, 1979) and hence in both occasions it is misperceived as anger. However, since the errors are limited, no generalized conclusion can be arrived at.

> When compared across lesion sites, some investigators have reported no significant difference between RHD with anterior and posterior lesions (Heilman et al., 1984). Others have reported better perceptual abilities of affective speech, by RHD with anterior lesion, when compared to RHD with posterior lesion (Tucker et al., 1977; Ross et al., 1988). In the present study, no particular pattern is observed, across the lesion sites, as performance of P1 is best among the three RHDs and performance of P2 is the worst, with subject A performing in between the two. But subjective impression of the patients based on interview and general conversation, revealed more perceptual problems among the subjects with posterior lesion. They took more time in understanding instructions and needed more practice trials. P2 performed poorly when compared to P1. This may have been due to different lesion areas in the posterior region, itself.

> When analysed across semanticaliy loaded and semantically neutral sentence type, both types of sentences were found to be affected equally. This is contrary to a study by Blonder et al., (1991), who

reported poor perceptual abilities for semantically neutral sentences. Since overall errors of perception are limited, nothing conclusive can be said about this variable.

These errors in perception are not consistent and cannot be accounted for wholly by the focal lesion in the right cortex. Subjects P1 and A have diffuse lesions in sub cortical areas as well, which could have also interfered with the perceptual abilities.

II Perceptual analysis of the subjects utterances by the judges

The judges perception of subjects utterances, in terms of deviation from the expected response, is given in a matrix form (Fig.2). In contrast to the matrix depicting perception of emotion by the subjects (fig.1), fig.2, depicts a substantial scatter in the production of specific emotions, by the subjects, as judged by the listeners.

> It is seen that even the normal subjects couldn't produce the right affect in their sentences, 100% of the time. Both the normals, had two of their productions being judged as depicting emotions, other than the target.

> In the posterior group, P2 has performed very poorly, with 16 out of 20, of his utterances being judged as deviant from the target. Most of his utterances couldn't be identified as one of the four target

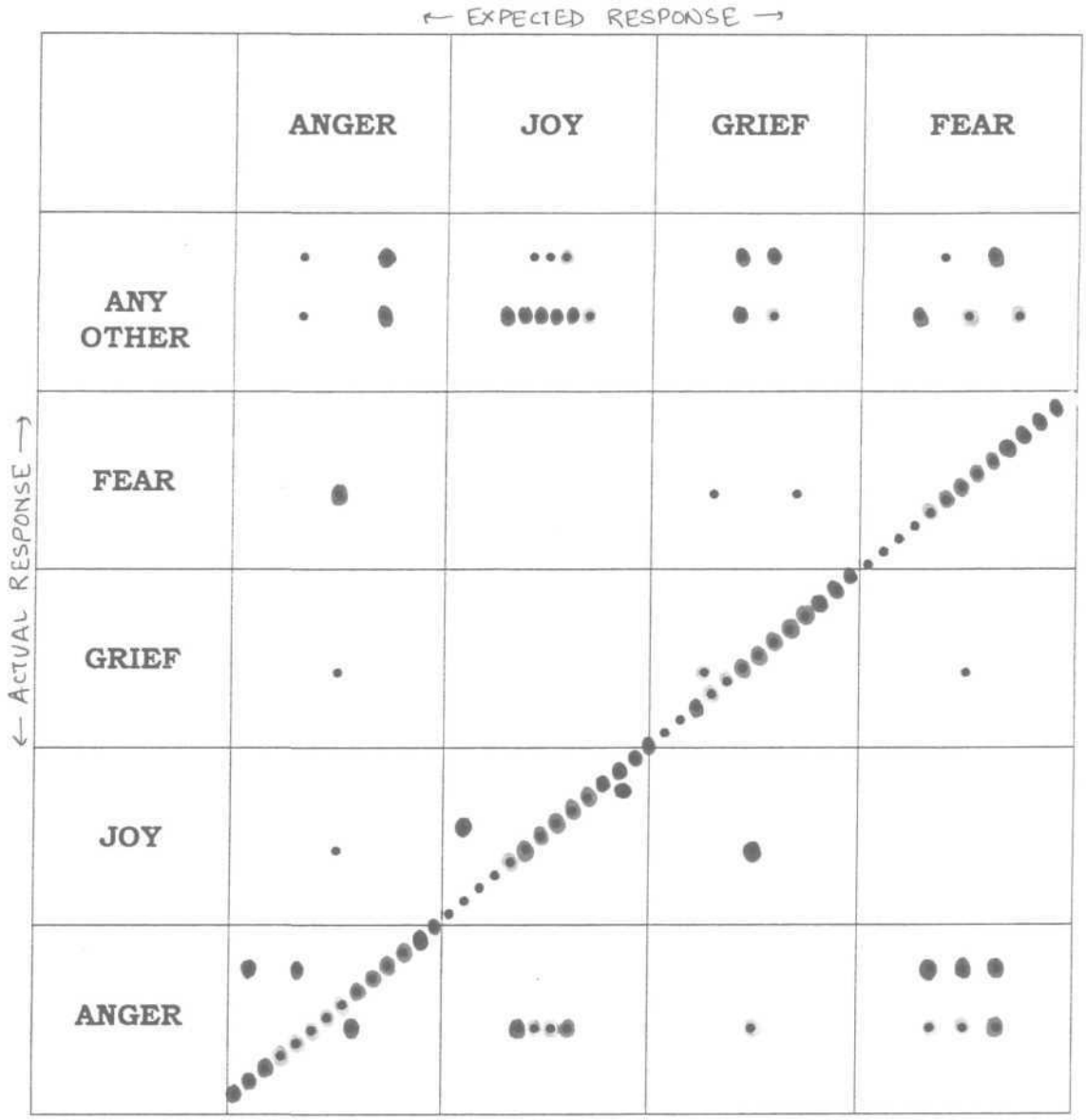


Fig.2 - Judges ratings of productions of normal (N) and RHD subjects across imitation Vs reading task

KEY - P1 (POSTERIOR) -
P2 (POSTERIOR) -
A (ANTERIOR) -
N1 (NORMAL) -
N2 (NORMAL) -

emotions. Often the judges identified the sentences as a statement, without depicting any particular emotion. Even in conversational speech, it is observed that he uses improper rhythm and affect in his speech. This subject also showed maximum errors in the perception task, among the group. It may be presumed that the perceptual deficit led to imprecise productions also.

The production of P1 is also poor compared to his perceptual abilities. His responses are judged to be deviant from the target. This may be partially due to the presence mild slurring in speech. This however, did not affect the overall intelligibility of his speech. In general conversation also, it is noticed that he had some confabulations and a tendency to add more words to the target utterance, in an attempt to enhance the meaning. His comprehension is normal but has rambling, excessive speech output.

These observations of two posterior subjects, find support in a study by Tucker, Watson and Heilman (1977), who report that lesion in right posterior areas can lead to deficit in both comprehension and execution of affective prosody. Many other studies report of poor perception, but normal expression in patients with right posterior lesion (Ross, 1981; Shapiro and Danly, 1985).

> In subject A (with anterior lesion) also, ten sentences are judged as being deviant from the target. Equal number are identified as one or the other four emotions. This subject has normal speech prosody, as observed during interview but imprecise affect productions were evident in the experimental task.

This finding is supported by several studies which report of poor expression of affective speech with intact comprehension, in patients with lesion in the right anterior cortex (Weintraub et al., 1981; Ross, 1981; Cooper et al., 1984; Danly and Shapiro, 1982; Shapiro and Danly, 1985).

> When analysed across emotions, joy is found to be produced differently, maximum number of times, followed by fear, then grief and anger (Fig.2). This is because subject P2 could not simulate joy and fear emotions at all. He could only produce anger appropriately to some extent. This poor performance for fear in production task, is also reflected in poor perception of fear. Fear, Joy require excessive variations in F0, which is not reflected in his monotonous voice. Anger is reflected relatively well, may be because it can be expressed by variation in intensity also, which is used as a cue by this subject.

It is interesting to note that Subject P1, on the other hand has more errors in simulating anger, than in other emotions. He could on the contrary produce joy and fear better than grief, which is opposite to what is observed for P2.

The performance of subject A is best in utterances with anger followed by grief. Poor performance is seen for both joy and fear; 50% of the time they are produced as anger. These observations can again be accounted for by wide F0 variations required for joy and fear which could be affected in this subject. Since grief has a very narrow range of F0 and anger can be cued by intensity variations, these emotions are produced appropriately, most of the times by this subject.

These findings find support in literature which reported of restricted F0 variation in patients with right anterior lesion (Shapiro and Danly, 1985).

> When analysed semantically loaded (SL) versus semantically neutral (SN) utterances in terms of number of errors, production errors are found to be almost equally distributed across both the categories. When studied individually across all subjects (Fig.3) slight variations are observed. For normals, ratings are same for

SL and SN, while for P1, ratings are more for SN than SL. For P2 and A, SN ratings are poorer than SL.

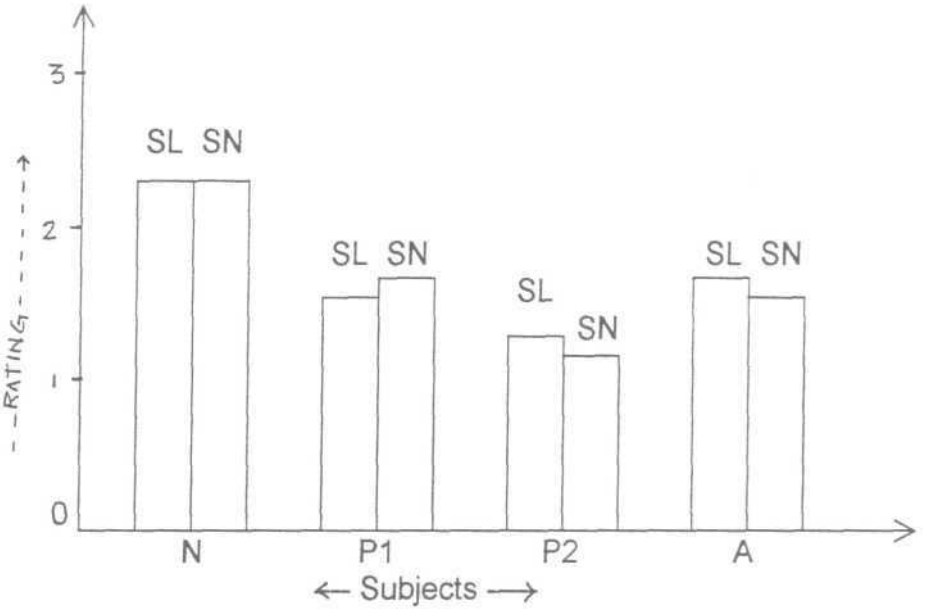


Fig.3 Judges ratings of productions of normal (N) and RHD subjects across SL Vs SN task

Studies have reported better production of semantically neutral sentences by right posterior and of semantically loaded sentences by right anterior lesion (Shapiro and Danly, 1985). Such observations are also made in subjects P1 and A. The results support those studies which believe that RHD patients have prosodic deficits which may not be specifically tied to an affective context (Weintraub et al., 1981; Danly and Shapiro, 1982; Cooper et al., 1984; Baum and Pell, 1997), and that the linguistic content of the utterance also affects the performance. Exception was observed in P2, where scores for SL sentences were slightly greater than SN showing better production of SL

sentences. This patient generally has more perceptual and production deficits than the other two subjects.

> When compared across imitation and reading tasks, in RHD group, better performance is seen in imitation task than for reading, except in P2 where performance is comparable across both the tasks. Even in normal group, performance is same across both tasks (Fig.4). Baum and Pell (1997) have reported better performance in imitation, except when perception problems are significant enough to interfere with production, hence supporting our findings.

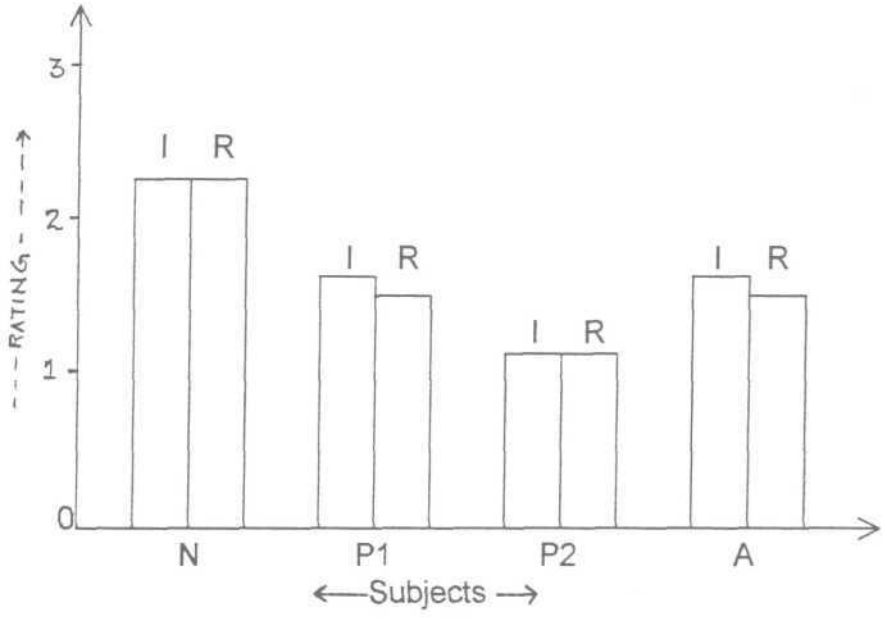


Fig.4 Judges ratings of subjects' productions across imitation and reading task.

III Acoustic analysis of utterances of subjects

(a) Primary stress/nuclear stress

It is the most prominent pitch accent in an intonation group, hence indicating the most prominent syllable (Cruttenden, 1986). The placement of nucleus, shows the focus of the sentence.

The primary stress placement in different emotions is compared among normal control subjects and RHD group. Each RHD subject is compared with his respective age matched normal subject. It is observed that all the three RHD subjects did not use the stress pattern as used by the normal subject. Fig.5 (a,b,c,d) depicts the placement of nuclear stress in the sentence with respect to time and its fundamental frequency. It can be seen that the RHD subjects did not stress the same syllable as normals, to indicate the focus or intention of their utterance. There is no consistent pattern in the placement of stress, by the RHD subjects, both with anterior and posterior lesion. Similarly no consistent pattern is observed across semantically loaded versus semantically neutral utterances.

However, when stress placement in reading and imitation tasks is compared, it is observed that more differences are seen in reading task than in imitation. This indicates that when given a

mode! the subjects could imitate and approximate stress in a required place, whereas in a reading task, they fail to stress appropriate segments in the sentence to communicate the affect.

It is also observed that the normal subjects placed stress on the same syllables, in both imitation and reading task. The RHD subjects, however shifted their focus (Fig.5 a,b,c,d).

Eg. Imitation:

N1 = ayyo simha bartaide

P1 = ayyo simha bartaide

Reading:

N1 = ayyo simha bartaide

P1 = ayyo simha bartaide

Hence, it is concluded that the production of primary stress, to indicate the focus of sentence, is affected in subjects with RHD.

(b) Maximum F0, Minimum F0 and Range of F0

Max. F0 : It is the highest F0 value in an utterance

Min. F0 : It is the lowest F0 value in an utterance

Range of F0 : It gives the difference between the Maximum and minimum F0 values.

Table 2 : Mean of Max F0, Min F0 and Range of F0, across four emotions, in normals and RHD group

EMOTIONS →	ANGER				JOY				GRIEF				FEAR			
MEAN OF↓	N	P1	P2	A	N	P1	P2	A	N	P1	P2	A	N	P1	P2	A
MAX. F0	25S	229	241	226	244	197	240	205	215	171	236	211	225	175	244	211
MIN. F0	106	95	114	93	103	117	159	78	97	139	96	95	112	115	88	90
RANGE	154	133	130	133	140	80	112	127	141	52	140	116	138	60	156	121

The results of F0 variation in terms of mean of Max. F0, Min. F0 and Range of F0, have been given in Table 2.

From Table 2, it can be observed that in normal subjects, mean of max F0 is highest for anger (258 Hz), followed by joy (244 Hz), fear (225 Hz), and grief (215 Hz). The range of F0 is also widest for anger (154 Hz) and narrowest for fear (138 Hz), which is comparable to the range for grief (140 Hz) and joy (141 Hz). These findings are different in some respects from that reported by Pell (1999), where the highest max. F0 and range was reported for happy utterances, followed by anger utterances. An earlier study by Baum and Pell (1997), reported equal mean F0 and range of F0 for anger and happy utterances, and reduced mean F0 and range of F0 for sad utterances. This observation finds support in the present study.

In the RHD group, for subjects P1 and A, a similar pattern as the normal subjects, is observed. But the overall values of max F0

and range of F0 is lower than normals. This suggests a limited ability to produce pitch variations and this in turn leads to production of an inappropriate affect. This is supported by literature (Ryalls et al., 1987; Baum and Pell, 1997),). Although range and max F0. for anger utterances of subject P1 is closer to normal values, they are much lower for joy, grief and fear. On the other hand, subject A has higher values than P1. This is contrary to the findings in literature, which report of limited variations for RHD subjects with anterior lesion and excessive or near normal variations for RHD with posterior lesion (Shapiro and Danly, 1985) or those which report of no significant difference between the two groups (Ryalls et al., 1987). This may be accounted for by the severity of lesion in the two subjects, with Subject A reported to have, a less severe damage than Subject P1. Subject P2, on the other hand differed slightly from the pattern observed for the rest. Although not distinct, he shows max. F0 for fear utterances (244 Hz) followed by anger (241 Hz), joy (240 Hz) and grief (236 Hz). Even the range is highest for fear utterances (156 Hz), followed by grief (140 Hz), anger (130 Hz) and joy (112 Hz). The values of this subject is even higher than that for the normals in fear and grief utterances. These findings find support to some extent in the literature that report of excessive, even more than normal, variations in the

posterior group of RHD patients (Shapiro and Danly, 1985). But no explanation can be given for the different pattern, in terms of the four emotions, observed in this subject.

From these results it is evident that RHD subjects, have difficulty in modulating the F0, to inflict appropriate variations suggestive of particular emotions. This also gives a subjective impression of monotony in their voice. Appropriate intonation could not be simulated even in the subject whose range was in excess to the normal.

(c) Declination

Declination of F0 means a constant downward drift in F0 (Cruttenden, 1986).

The regression line model and the zero line model are in general, the two methods used to describe declination in various languages (Lado, 1961). The regression line method (Cooper and Sorenson, 1981) maintains that declination is manipulated by abstract lines drawn through selected stress peaks in the actual contour. Regression line model is found to be better in defining more specific pattern of slope and shape of declination in Kannada language (Manjula, 1979). Slopes of declination is generally described as rising or falling, from the syllable initial to the syllable final position.

In this study, the declination slopes observed for normals and RHD subjects, across the four emotions are analysed and they are given in Table 3.

Table 3: Declination across four emotions in Normal and RHD subjects.

EMOTION→ SUBJECTS↓	ANGER		JOY		GRIEF		FEAR	
	R*	F**	R	F	R	F	R	F
N	4/4	-	-	4/4	-	4/4	4/4	-
P1	3/4	1/4	-	3/3	2/3	1/3	3/4	1/4
P2	3/3	-	4/4	-	2/4	2/4	-	4/4
A	1/4	3/4	3/3	-	-	3/3	-	4/4

* R = Rising declination

** F = Falling declination

In normals, a rising declination is seen for anger and fear, and a falling one for joy and grief. These patterns have been reported in literature also (Bolinger, 1981).

In the RHD group, a variable pattern is observed. P1 and P2 show a rising declination for anger, like the normals, but subject A shows a falling pattern. For joy, P1 shows a falling slope while the other two show a rising slope. A falling slope is observed for fear in P2 and A. On the other hand P1, shows both the patterns, though more of rising. In grief utterances, a mixed pattern is seen, with, P1 and P2 showing both rising and falling pattern, while subject A showing a falling pattern.

From these observations, it is seen that subject P1 is successful in matching the normal control subjects declination slope, to some extent. Hence he is able to approximate the intonation contour, but with limited variations. Subject P2 differs from normals, in two instances, while subject A differs in three instances. This indicates expressive limitations of affective prosody, by subject A (one with anterior lesion).

These results lead to an observation of poor speech motor control in subjects with RHD, as is exhibited by variable patterns across all the emotive.

(d) F0 contour of the utterance

F0 contour depicts the movement of F0 over the sentence. Specific contour movements for different types of sentences and emotions are reported in literature (Ladefoged,1967; Jones, 1964). These contours may differ across languages. In Kannada language, affective sentences are expressed with a final fall (Manjula, 1979). Nandini (1985) reported of a Rise-Fall (R-F) pattern for anger. She also reported that same kind of intonation patterns may be used to express different types of sentences and the differences if any, would be in terms of the gradient of slope (steep or gradual).

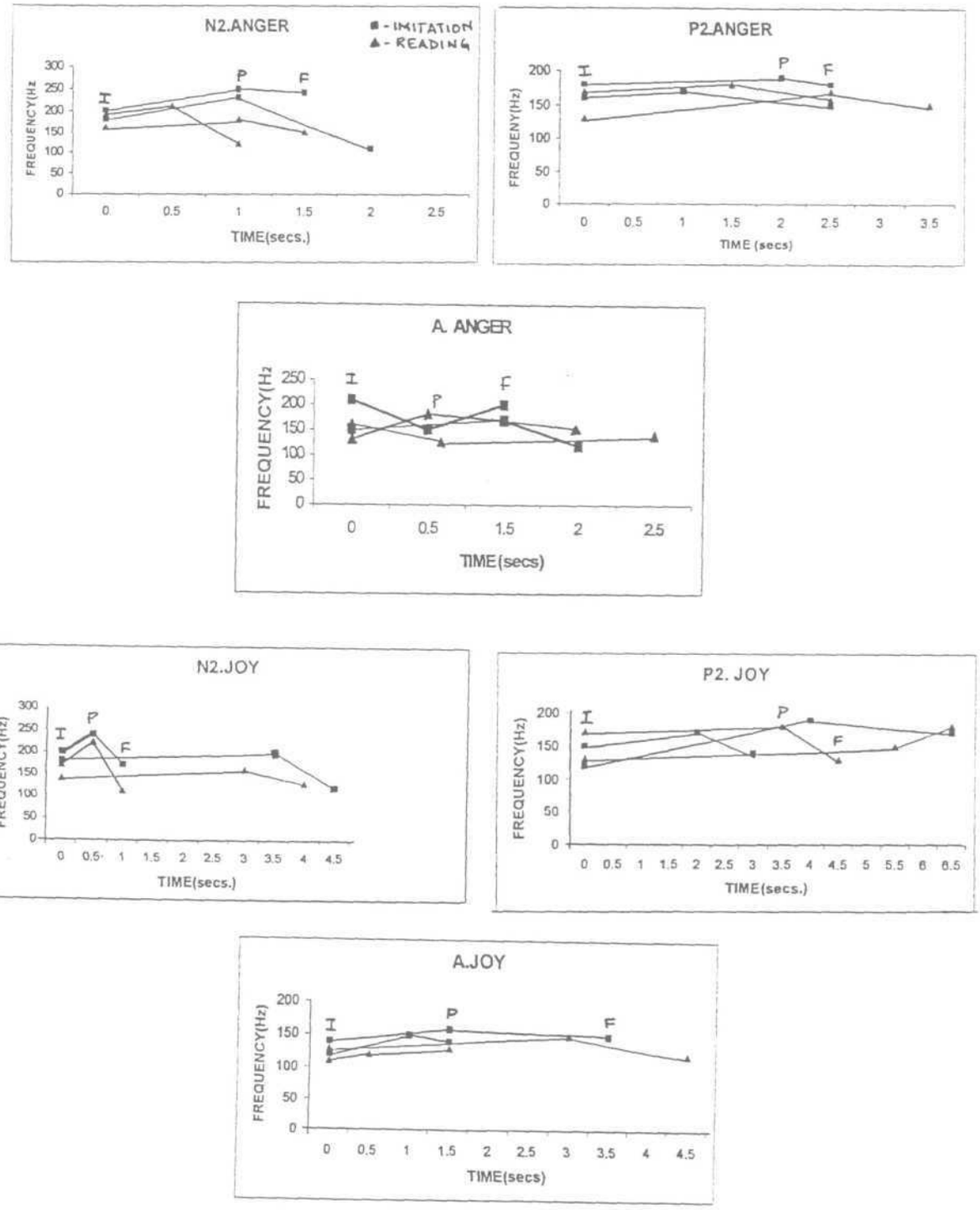


Fig.5 (a) - Initial syllable F0, primary stress F0, final syllable F0 in RHD and normal subjects.

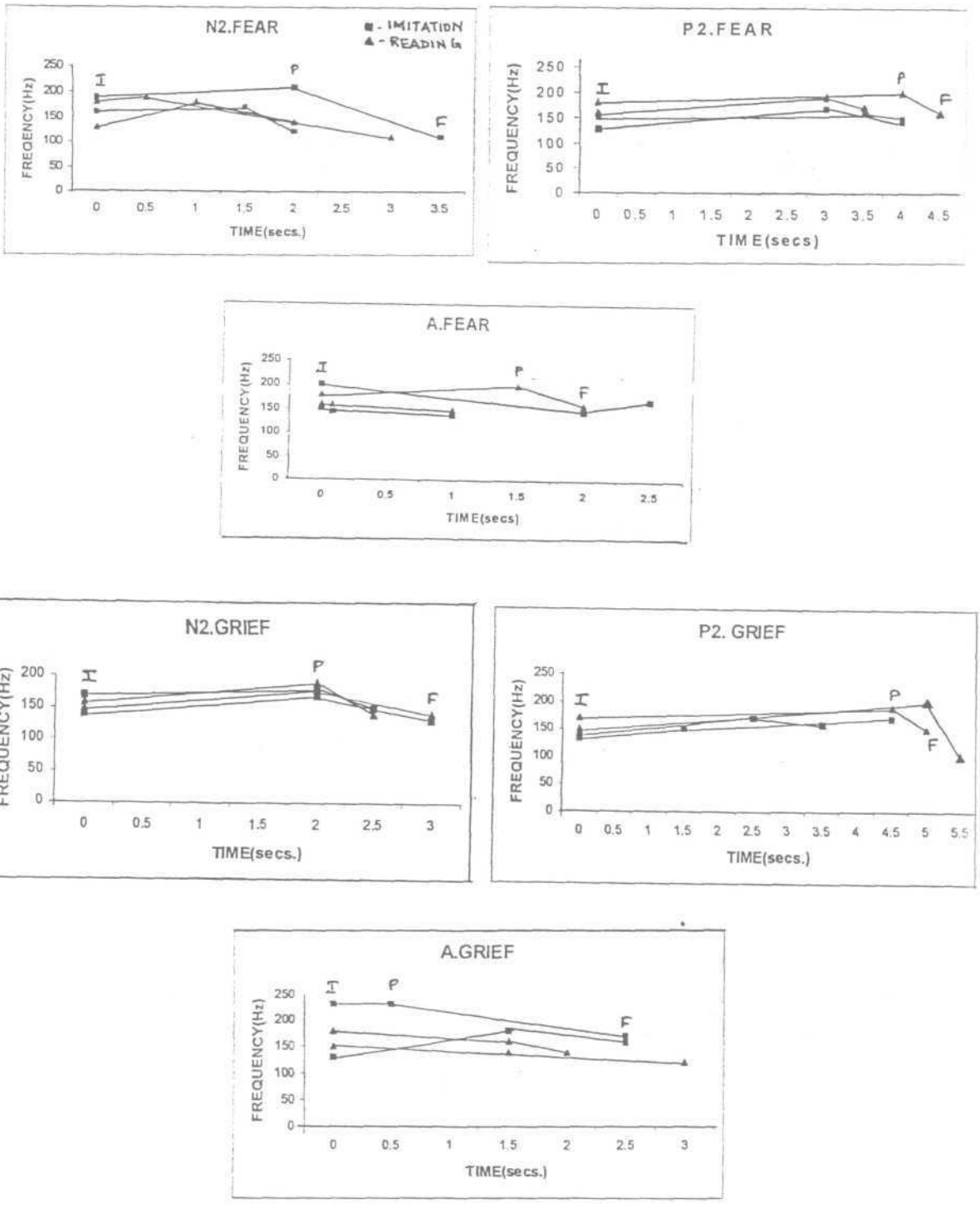
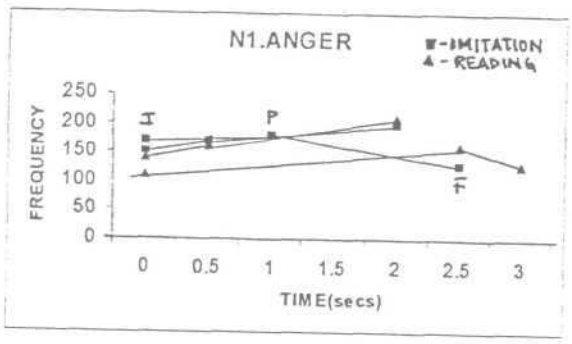
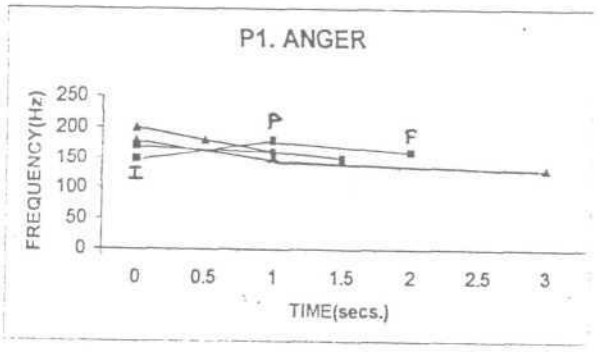
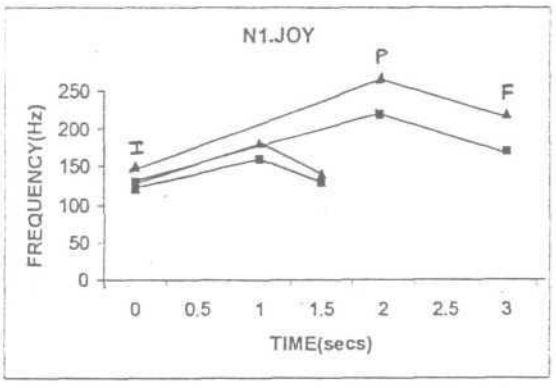


Fig.5 (b) - Initial syllable F0, primary stress F0, final syllable F0 in RHD and normal subjects.







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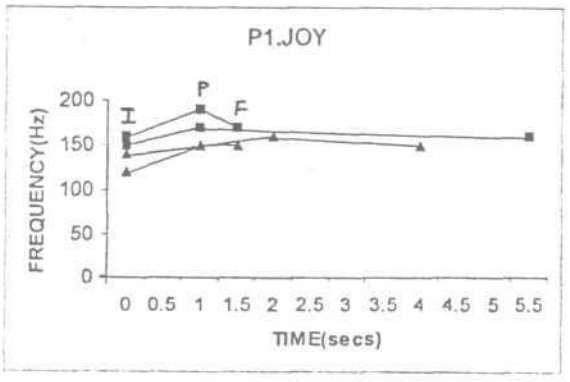
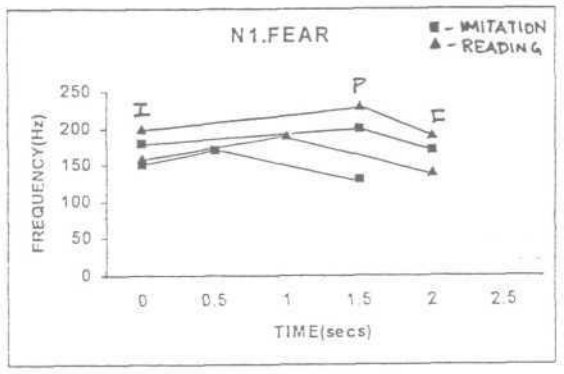
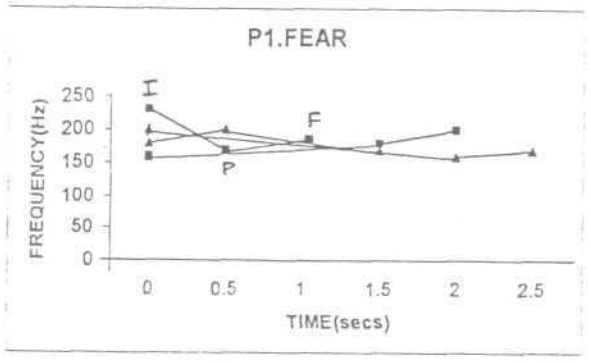
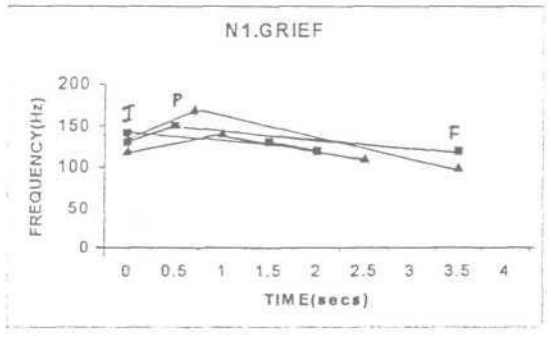


Fig.5 (c) - Initial syllable F0, primary stress F0, final syllable F0 in RHD and normal subjects.







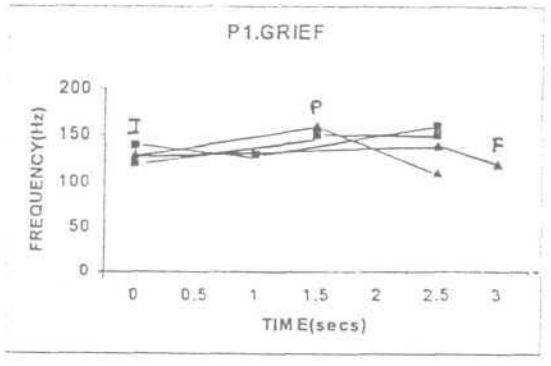


Fig.5 (d) - Initial syllable F0, primary stress F0, final syllable F0 in RHD and normal subjects.

Fig. 5 (a,b,c,d) depicts the overall movement of F0 over the utterance. These are not the exact representation of the contour, but give an approximate picture. The three points in the graph represent the initial syllable F0, primary stress and final syllable F0. Thus from Fig.5 (a,b,c,d) it is seen that the normal subjects have consistently expressed different emotions, with specific contour movements. Anger has normally been expressed with a steep rise - steep fall (R-F) contour, except in one of the normal subjects who has expressed with a steep rise pattern, in some instances.

Joy and fear has been consistently produced with a R-F contour, but fear is produced with a gradual slope. Grief is also produced with a R-F contour, but more inconsistently than other. These results are consistent with those reported for normals in Kannada language, in that all of them are ending with a falling contour (Manjula, 1979).

In the RHD group, it is seen that though some of the normal contours have been imitated, some variations are still present. Subject P1 partially succeeded in imitating the R-F contour for joy and anger but the slope was more gradual for both emotions (Fig.5 c). This may be because of increased sentence duration used by the subject. In utterances expressed with grief (Fig.5 d),

in one instance a rising pattern was observed, though the rest had a R-F contour. In fear (Fig.5 d), all four sentences had different contour shapes - R-F, F-R, only R, and very gradual F-R. Since fear is an emotional expression which requires a good control over the pitch control mechanism to convey the subtleties in expression, it can only be presumed that the subject lacked this control.

Subject P2 is able to imitate all the contours like normal that is, R-F, but with an increased duration for all emotions (Fig.5 a,b). Generally there is a slow rate of speech, which is reflected in expression of emotions as well. Surprisingly though, the production of his utterances is rated to be worst, by the judges. It means that although the subject's emotive sentences are perceptually indistinct, his productions, as characterized by the acoustic analysis, has been effective in conveying the fine acoustic attributes.

Subject A is also able to match the normal contour, but not as well as Subject P2. Variation in contour is seen in some instances of anger (F-R), grief (only F), joy (only R) and fear (F-R). In some instances the duration is even shorter than that of the normal subject (Fig.5 a,b).

From these results, it can be seen that though the RHD subjects are able to match the normal contours, several variations exist which are difficult to account for. This only reflects that they have limited capacity to bring out the appropriate affect in their speech.

Fig.5 (a,b,c,d) also tells us about the initial syllable F0 and the final syllable F0 . In normal subjects N1 and N2, it is seen that generally the initial syllable (ISF0) is at a higher level than final syllable F0 (FSF0), though some variations from the general trend are also seen. This finding is supported by literature also (Bolinger, 1981). But the same trend is not observed in the RHD group as a whole. In fact, no particular trend is seen across emotions, as well. Not much has been reported in literature about this variable.

The results of the study for RHD subjects may be summarised as follows:

(i) Relatively intact perceptual abilities when compared to production. Slightly poor performance by the Subject P2 (posterior). Subjective assessment also revealed an overall comprehension defidts in RHD subjects with posterior lesion.

Analysis across emotions shows that grief is perceived erroneously most often. Grief, being a subtle emotion, which has limited variations in acoustic parameters, needs more finer control and the RHD subjects were poor in the perception of these subtle changes. No significant difference is seen in performance of semantically loaded versus semantically neutral sentences, across the emotions, as well as the subjects.

(ii) The expressive skills, on production of affective sentences were much poorer than perceptual skills. Subject P2 performed very poorly with sixteen of his twenty utterances being perceived as a different emotion, by the judges. The other two subjects P1 and A also did poorly when compared to their relatively intact perceptual abilities.

> Analysis across emotion revealed maximum errors for joy followed by fear, grief and lastly anger. Subjects P2 and A have done poorly on joy and fear, while subject P1 has more errors in simulating anger.

> Analysis across semantically loaded versus semantically neutral sentences, again shows a comparable performance across both types of sentences. Individual variations, however are seen across the subjects.

> Comparison between imitation versus reading tasks, reveals better performance in imitation task, for subjects A and P1. Subjects P2 and the normal controls had comparable scores for both the tasks.

(iii) Acoustic analysis of the subjects utterances has been done across different parameters -

> Nuclear stress - The RHD, as a group, have shown differences in placement of stress, when compared with normal controls. No specific pattern is observed and also no consistency is seen across imitation and reading task when compared to normal controls.

> Max F0, Min F0 and Range of F0 - In normal subjects, max. F0 is seen for anger followed by joy, fear and grief, in a descending order. The same order is seen for subject P1 and subject A, but an overall reduction in max. F0 and range of F0 is also evident. Subject A has higher values than subject P2, which is contrary to that reported in literature.

Subject P2 follows a different order from the rest. He has max. F0 for fear, then anger, joy and grief. Even range is highest for fear utterance. The values for this subject is seen to be even

higher than normals control in several instances. This confirms with the literature on RHD.

> Declination - In normals, rising declination is seen for anger and fear, and a falling one for joy and grief. In RHD group, a variable pattern is observed. Subject P1, to some extent, was successful in mimicing the normal declination slope. Subject P2 and A differ from the normal in several instances.

> F0 contour - The normal subjects have shown a definite pattern of R-F, which has also been reported in the literature (Manjula, 1979; Nandini, 1985).

In the RHD group, subject P2 has been able to imitate the normal like contours but with a prolonged duration. Interestingly though, his perception has been the most deviant and also his utterances are rated poorly by the judges. Subject A, has been able to imitate normal contours but not to a great extent. Variations in contour are seen in some instances. Subject P1 has been able to imitate joy and anger contours but not grief and fear.

> Initial syllable F0 and final syllable F0 - They have been depicted in Fig.5 (a,b,c,d). In normals, generally ISFO is higher than

FSF0, though slight variations are noticed in some instances. No particular trend is seen in the RHD group.

A qualitative assessment of the subjects with RHD, during interview, has shown certain inconsistencies in performance of each RHD subject. Though subject P1, has shown near normal scores, in the perception task, he did exhibit some comprehension deficits in normal conversation. He needed repetitions for instructions. His expressive skills also had shown some confabulations in speech, and addition of irrelevant phrases in between the target sentences. This was not reflected in his overall performance on imitation of model utterances. He did better than the subject P2 and could also match the normal FO contour in many instances.

> Subject P2 had a very deviant rhythm pattern, which was observed during the experiment, as well as during general conversation. His comprehension was noticed to be mildly affected during general conversation. This subjective impression, was also evident in his poor performance in both production and perception tasks. He also had a slow rate of speech, which combined with a deviant rhythm pattern, led to very different intonation pattern of all the utterances, when perceptually analysed. Surprisingly, these deviations did not

result in significant deviations on the contour movement, which approximated those of normals. Temporal parameters were prolonged and placement of stress was also very different.

Subject A, had almost normal expression and comprehension abilities, when assessed during interview and general conversation. His performance, on perception task was relatively normal, so was his production when acoustically analysed. Except for a limited range and reduced duration (in some instances) other deviations in acoustic features was not very significant. Thus, it is important to assess an individual with neurological impairment on a global basis to derive at a comprehensive profile of his/her communicative limitations.

SUMMARY AND CONCLUSION

Patients with damage limited to their right hemisphere can have a variety of deficits. Some of them affect communication and cognition directly, and some exert indirect effects on the ability to participate in communicative events and to interact successfully with the environment (Myers, 1999). In a brief conversation, they may not appear to have any significant communication deficits, but it may become apparent in extended and complex conversation.

Prosodic impairments, specifically affective prosody in RHD individuals, has gained attention of speech language pathologists only since last three decades. Several studies have been done since, on the perception and production abilities of RHD individuals, in both affective and linguistic context. Most of them report of a deficit in perception and/or production of affective prosody, than linguistic prosody (Heilman, et al., 1984; Blonder et al., 1991; Borod, et al., 1992; Schmitt et al., 1997). Hence, these studies support a right hemispheric lateralisation of affective prosody. Some studies however, report of a participation of both the hemispheres, in processing affective prosody (Van Lancker and Sidtis, 1992; Baum and Pell, 1999). They report of lateralisation of specific features, which convey intonation, that is, temporal parameters to left hemisphere and frequency parameters to the right hemisphere.

Studies, connecting the lesion location to the deficit type, have also been inconclusive. Some investigators have tried to correlate the areas of right cortex to those of left, in that, lesion in a specific area would mimic a particular type of aphasic syndrome, in terms of comprehension and expression of speech prosody (Ross, 1981; Gorelick and Ross, 1987). Others have refuted this notion (Danly and Shapiro, 1982; Basso et al., 1985; Schaienger, et al., 1976; Cancelliere and Kertesz, 1990). Studies on acoustic analysis of the speech of RHD patients have generally reported of a restricted range of Fo, suggesting that the speech is monotonous (Shapiro and Danly, 1985; Pell, 1999). Nothing much has been reported about the other F0 parameters of intonation like, nuclear stress in the primary contour and pre contour initial and final syllable F0.

Prosodic functions are specific to different languages. Though a few studies have been done in Kannada language, on intonation features in normal population (Deva, 1957; Rathna et al., 1976; Manjula, 1979; Nataraja, 1981; Nandini, 1985), nothing is reported on the performance of RHD individuals, on affective intonation tasks. Hence the present investigation was taken up with an aim to study the perception and production of affective intonation in RHD individuals with anterior and posterior lesion, across semantically loaded versus semantically neutral sentences, in imitation and reading tasks. The performance of the RHD subject was analysed both perceptually and acoustically.

Methodology - Three RHD subjects (two with posterior lesion and one with anterior lesion), with their age and gender matched normal control subjects, were selected for the study. They were evaluated on two tasks - perception and production. In the perception task, they were asked to judge the emotions conveyed by ten model utterances of Kannada. They had to make a closed choice out of four-anger, grief, fear and joy and were also given the option to report any other emotion perceived. In the production task, they were asked to imitate the same sentences, producing the same affect that they perceived, after the model utterances. In another task, they were given graphic cues of the same sentences and were asked to produce the required affect. Two types of sentences, were also considered - semantically loaded (SL) and semantically neutral (SN), for all the emotions. The utterances of the participants were subjected to both perceptual and acoustical analysis. Three judges were selected for perceptual judgements. Acoustical analysis was carried out using the speech analysis software of "VAGHMI" of the Voice and Speech Systems (VSS). The INTON program was used to extract the fundamental frequency, intensity - curves and speech waveform. The following F0 parameters were studied -

1. F0 of primary stressed syllable
2. (a) Maximum and minimum F0
   (b) Range of F0
3. Variation in F0 (Contour)
4. F0 of initial and final syllable
5. Declination of F0

The results of the present study are summarized in Table 4.

Table 4: The performance of RHD subjects, on the various tasks, when compared to normal control subjects.

TASK	SUBJECT P1	SUBJECT P2	SUBJECT A
(1) Perception of model utterances	Relatively intact	Poor	Relatively intact
(2) Judges rating of subjects productions	- poor - most affected for anger - SN better than SL - imitation better than reading	Very poor - Most affected for joy and fear - SL better than SN - Imitation comparable to reading	Poor - Most affected for joy and fear - SL better than SN - Imitation better than reading
(3) Acoustic analysis of subjects production			
→ Nuclear stress	Did not follow normal pattern of stress placement across the utterance		
→ MaxF0	Lower than normals	Lower than normals in Anger and Joy, but higher in Grief and Fear	Higher than P1 but lower than normals
→ Range of F0	Reduced	Increased in grief and fear and reduced in anger and joy	reduced
→ Declination	Variable	Variable	Variable
→ FO contour	RF contour for joy and anger like normals -More gradual slope	RF pattern for all emotions, but with an increased duration for all utterances	RF contour for most of the utterances, but varied in some instances Duration even shorter than normals in many instances.
→ Initial Syllable F0 and → Final Syllable F0	No particular trend observed as done so for the normals (ISF0 higher than FSF0)		

Note: SL = Semantically loaded, SN = Semantically neutral

R= Rise , F= Fall

Conclusions

The results of the present study yielded some interesting findings.

> The results of perceptual task and acoustical analysis varied significantly. The perceptual abilities of the subjects were much better than their expressive skills, even in the RHD subjects with posterior lesion. Hence the null hypothesis stating no difference between perception and production of emotive intonation is rejected.

> The deviancies in prosody, which were not too evident in the perceptual tasks of emotive utterances, clearly revealed a pattern in the acoustic analysis. The results obtained on acoustical analysis highlights the importance of objective measures in assessment of neurologically impaired subjects, including RHD.

> The subjective impression of the RHD subjects during the interview, revealed that posterior RHD individuals had more perceptual problems than anterior RHD. These observations matched the results of acoustical analysis also.

> The performance of subjects across semantically loaded and semantically neutral sentences was comparable. Hence we can accept the null hypothesis that states, no difference between semantically loaded versus semantically neutral sentences in all the tasks.

> There was however a difference seen in imitation versus reading task. The performance of all the subjects was better for imitation than reading, suggesting better abilities in matching intonation when given a model. Thus supporting better perceptual abilities for intonation than the abilities to produce the name voluntarily. The hypothesis which states that there is no difference between performance on imitation versus reading task is also rejected.

> The results of acoustic analysis shows : (a) An overall reduction in the range of F0 indicating limited capacity to bring variations in intonation. (b) RHD subjects with posterior lesion had prolonged most of their utterances, while the one with anterior lesion had, in some instances, durations even less than normals. (c) The placement of stress in all these subjects was deviant from the normal group.

> On interesting observation that was made during the course of the study, was that within the posterior group of RHDs also, differences in performance was noticed. Subject P2 generally performed poorly than P1. This leads to the conclusion that even though the lesion was restricted to posterior regions of the right cortex, the actual site of lesion varied. Subject P1 had involvement of sub cortical structures also. Therefore, future researches should also focus on these areas as well.

Recommendations for future research

> The same study can be replicated with more number of RHD subjects, in each group (anterior and posterior).

> Studies can be done taking subjects with lesions in specific sites, within posterior or anterior region, to delineate the role of specific sites in the right cortex, in communication.

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APPENDIX - A

SCORING SHEET (ಸ್ಕೋರಿಂಗ್ ಶೀಟ್)

S.No. ಕ್ರ.ಸಂ.	JOY ಖುಷಿ	ANGER ಕೋಪ	FEAR ಭಯ	GRIEF ದುಃಖ	Any other ಇತರೆ
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

APPENDIX - B

Anger (ಕೋಪ)	1. ನಿನ್ ಮುಖ ನೋಡೋಕ್ ನಂಗೆ ಇಷ್ಟ ಇಲ್ಲ 2. ನನಗ್ ತಿರುಗಿ ಮುಖ ತೋರಿಸ್ಬೇಡ 3. ಇಷ್ಟೊತ್ತ್ ಎಲ್ಲಿದ್ದೆ ? 4. ಬಾಗಿಲು ಮುಚ್ಚಿಲ್ಲ ನೀನು
Joy (ಖುಷಿ)	1. ನಂಗೆ ಎಷ್ಟು ಖುಷಿಯಾಗಿದೆ ಅಂದರೆ ಕುಣ್ ಕುಣ್ದಾಡೋಣ ಅನ್ನತ್ತೆ 2. ನಂಗೆ ಹೊಸ ಬಟ್ಟೆ ತಗೊಳ್ಳೊಕ್ಕ ಹೋಗೋದೂಂದ್ರೆ ಬಹಳ ಮಜ ಕೊಡುತ್ತೆ 3. ಅಪ್ಪ ಮನೆಗೆ ಬಂದ್ರು 4. ನಾನ್ ಊರಿಗೆ ಹೋಗ್ತೀನಿ
Grief (ದುಃಖ)	1. ನಾನ್ ಎಷ್ಟೆ ಕಷ್ಟ ಪಟ್ರೂ ಆ ಕೆಲಸ ನಂಗೆ ಆಗ್ಲೇಯಿಲ್ಲ 2. ಆ ಅಪಘಾತದಲ್ಲಿ ತುಂಬಾ ಜನ ಸತ್ಹೋದ್ರು 3. ಅವನು ತಿರುಪತಿಗೆ ಹೋದವನು ಬರ್ಲೇ ಇಲ್ಲ 4. ಹೀಗೆ ಮಾಡೀನೇ ಅವನ್ ಜೀವನಾಯೆಲ್ಲಾ ಹಾಳಾಯ್ತು
Fear (ಭಯ)	1. ಅಯ್ಯೋ ! ಸಿಂಹ ಬರ್ತಾ ಇದೆ 2. ಸುಳ್ಳ ಹೇಳಿದರೆ ನನ್ ಅಪ್ಪ ಹೊಡ್ದ್ ಚಚ್ಬಿಡ್ತಾರೆ 3. ನಾಯಿ ಬರ್ತಾ ಇದೆ 4. ಅವನು ನಿನ್ನನ್ನ ಹುಡುಕ್ತಾ ಇದ್ದಾನೆ