ANALYSIS OF INFANT CRY

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DEDICATED TO

My ***Parents***, who gave me their faith, borrowed my troubles, gave me their love and patience.

&

MY RESPECTED GUIDE

&

Small ***"GANESHA "*** - external power who gave strength and made me what I am.

CERTIFICATE

This is to certify that the dissertation entitled **"ANALYSIS OF INFANT CRY"** *is the bonafide work in part fulfillment for the degree of Master of Science (Speech of Hearing), of the student with Register No. M 9623.*

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CERTIFICATE

This is to certify that this dissertation entitled "ANALYSIS OF INFANT CRY", *has been prepared under my supervision and guidance.*

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DECLARATION

This dissertation entitled **"ANALYSIS OF INFANT CRY",** *is the result of my own study under the guidance of* **Dr. N.P.Nataraja.** *Professor and Head of the Department of Speech Sciences, All India Institute of Speech of Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.*

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CHAPTER - I

INTRODUCTION

But what am I ?
An infant crying in the night;
An infant crying for the light;
And with no language but a cry.

- Alfred Lord Tennyson
(1809 - 1892)

'Random', 'non expressive' and 'diffuse' and similar terms have been used to describe the utterances of babies (Gesell, 1940; Osgood 1953; Spitz, 1963). 'During infancy, the child's only mode of communication is the cry, and we should listen to his vocalization and try to interpret it. When a baby is ill, the parents too are most eager and anxious to have some explanations of his prognosis and possible life long defects. Any method which could provide further enlightment should be thoroughly explored'. (Sjruio & Michelson, 1976). In human vocalization and also in crying the entitled sound is a combination of a function frca the brain, from the larynx and oral cavity (Espir and Rose, 1970; Perkins, 1971).

The general answer to why we should analyze infant cry, is at least one which according with view, stated by Liberman.

". . . . . . .biological substrate of human speech involves an interplay between biological mechanism that have other vegetative functions and neural and anatomical mechanism that appear to have evolved primarily for their role in facilitating human communication".

It is important to emphasize that crying is not just a reflection of only the physiological state of infant. Increasingly, a number of researchers are beginning to view crying and its perception as an interpersonal event. (Boudkydis, 1955). That is crying is considered as a social event and as a system of communication. It may serve as a preverbal distress signal. There is now a increasing body of research documenting systematically this aspect of crying and consequences of its perception and response by care given. For clinical purpose, crying and other vocalization are signals which can be used to evaluate to neuro respiratory and phonatory functions of infants. It is this reason that there has been so much interest in cries of high risk new born.

Unusual cry is caused by some disturbances (or) abnormality some where in this complex chain of events. This disruption could be due to faulty neural control of respiration (or) phonation as might be produced in Cri-du-Chat syndrome. Down syndrome (or) damage due to recurrent voice etc. (or) it could *be* produced by some disarrangement in the airway itself. Reforming sophisticated analysis of the unusual cries (specifically acoustic analysis) we would be able to detect and locate site of this disturbance. This is one of the real clinical purpose in pursuing infant cry analysis. That is, we ought to be able to differentially diagnose the drfference between subglottal, periglottal and supraglottal sites of disturbances as well as detect the difference between airway and nervous system origin of abnormality. This is diagnostic significance of acoustic analysis of infant cries and vocalizations (Gopal and Gerber 1991). Cry analysis can thus be diagnostic and prognostic criterion in disease in neonatal period. Early diagnosis is very important because treatment when started early enough diminishes later defects. (Maenpaa 1972).

The objective techniques for analyzing infant cries are by volume unit graph (Fisichelli, Karelitz, Eichbar and Rosenfield, 1961) and computer analysis (Ostwald and Feitzman 1974). A number of investigators have employed acoustic analysis of various sorts of both normal and abnormal infants. For example, for over 30 years several Finish and Swedish researchers have used sound spectrograph and conducted systematic acoustic analysis of cries. They have provided large amount of acoustical data on cries of normal infant. This vast body of research has provided much of justification and inspiration for using acoustic analysis of cries as and additional diagnostic tool in clinical paediatrics. Using spectrograph, crie3 of normal infants and those infants with various abnormalities have been differentiated based on various parameters of cry. (WAsz-Hockert etal 1971; Michelsson 1971; Michelsson et al 1975; Sivisio - Michelsson 1976). Based on previous literature a need to differentiate between normal and abnormal infants, the purpose of present study will be to analyze cries of normal and abnormal infants by spectrographic analysis and to note specific characters which will be distinctive to each abnormality.

The aim is to test the following hypothesis, "No significant difference exist between cries of normal healthy infants and infants with history of high risk factors (or) other problem on the following cry characteristics - pitch (minimum and maximum), shifts, glide, melody type, glottal plosive, vibrato, tonalpit, Double harmonic break, biphonation, furcation, noise concentration, total duration and second pause of cry signal.

Sub hypothesis:

1. No significant difference exists on various parameters derived using spectrogram between cries of normal infants and infants with low birth weight.

2. No significant difference exist on various parameters derived using spectrogram between cries of normal infants and infants with metabolic disorders.

3. No significant difference exist on various parameters derived using spectrogram between cries of normal infants and infants with hydrocephalus.

4. No significant difference exist on various parameters derived using spectrogram between cries of normal infants and infants with Jaundice.

5. No significant difference exist on various parameters derived using spectrogram between cries of normal infants and preterm infants.

6. No significant difference exist on various parameters derived using spectrogram between cries of normal infant and infants with Asphyxia.

7. No significant difference exist on various parameters derived using spectrogram between cries of normal infants and infants with respiratory disorders.

8. No significant difference exists on various parameters derived using spectrogram between cries of normal infants and infants with meconium aspiration.

9. No significant difference exist on various parameters derived using spectrogram between cries of normal infants and infants with history of fits.

10. No significant difference exist on various parameter derived using spectrogram between cries of normal infants and infants with other risk factors (like T.E.P. fistula, leg deformity and hearing loss).

Brief plan of the study

1. Administration of a list of high risk factors and collection of information from parents of normal and abnormal infants.

2. Collection of data from the infants (pain cries to be elicited from infants by flicking sole of infant's foot with index finger till they cry for atleast 30 seconds. The cries are to be recorded).

3. Spectrographic analysis of recorded sample to be done on the various selected parameters.

Need & Implication for the present study:

- Acoustic analysis of infant cry using spectrography is totally non-invasive techniques. Most other techniques employed in the diagnosis of sick babies are invasive (ex. endoscopy, blood test etc.). The process of administering some of these invasive test and techniques themselves carry varying amount of risk to the infant. Invasive technique require waiting until infant is of appropriate age to some tests. However with recording and analysis of birth cries, the moment of birth itself offers data for an evaluation of infant.

- It will help to differentiate between normal and abnormal infants.

- Infant cry analysis is a valuable tool in differential diagnosis of different abnormalities of infants.

- Using for early identification of abnormalities and thus in early rehabilitation (or) treatment.

Thus acoustic analysis by spectrograph is a powerful objective technique. Applying such powerful technique to infant cries and vocalization may hold a lot of promise in understanding infant cries of both normal and high risk infants.

Limitation of the present study:

1) A small number of infants were included in each high risk category.

2) Only limited number of high risk categories were studied.

3) Only one follow up examination of the infants were done.

PARAMETERS USED IN THE PRESENT STUDY

I. Durational Features:

1) Duration:

The duration of the cry signal after the pain stimulus is the time from the onset of crying to the end of the last phonation before inspiration independently of whether the signal is continous (or) consists of several short phonations.

2) Second Pause:

The time interval between the end of the signal and the following inspiration.

II. Fundamental Frequency Features:

1) Minimum Fundamental Frequency:

Refers to lowest measurable point in the fundamental frequency seen on the spectrogram.

2) Maximum Fundamental Frequency:

Refers to highest measurable point of fundamental frequency seen in the spectrogram.

3) Melody Type:

Melody type of the fundamental frequency has been classified as falling, rising - falling, rising, falling - rising and flat.

There should be atleast a 10% change in pitch level during more than 10% of the duration of the cry for melody type to be identified.

4) Vibrato:

In considered to have occurred when at least four successive rapid up and down vibration have been noticed. These appear more clearly in the upper harmonics.

5) Shift:

Denotes an abrupt upward and downward movement of the fundamental frequency and has been included in the measurements when it exceeds 0.1 seconds.

6) Glide:

Is a rapid up and (or) downward of the fundamental frequency. The change in frequencies must be atleast GooHz in 0.1 seconds.

7) Tonal Pit:

Is rapid upward and downward movement in the fundamental frequency. Here full in pitch exceeds 30% and occur within 0.4 seconds.

8) Noise Concentration:

Refers to a clearly audible high energy peak of 2000-2500 hz found both in voiced and voiceless parts of the signal.

9) Double harmonic breaks:

Is defined as a parallel series of harmonics which have the same melody form as the fundamental frequency and occur simultaneously with the fundamental.

10) Furcation:

Is a term denoting a split in the fundamental frequency where a relatively strong cry signal suddenly breaks into a series of weaker ones, with each of them having its own fundamental frequency contour.

11) Biphonation:

Is considered as a double series of fundamental frequencies, but the two (or) more series donot have a parallel melody form.

12) Glottal plosive:

Sudden release of pressure at the vocal folds producing an impulsive expiratory sound.

CHAPTER - II

REVIEW

"Crying is one of the first way in which the infant is able to communicate with the world at large" (Ostwald and Petzmar, 1974). Crying is a behavior, infact, it is a sequence of behavior pattern that is part of the larger behavioral repertoire of the infant and for the neonate and young infant, crying is the primary mode of expressing and communicating basic needs and events. It is a social behavior that has powerful effects on the parent infant relationship and it elicits strong emotions in parents. The cry is also an acoustical event that not only affects care givers but also contains information about the functioning of the infants nervous system. Finally as a form of communication, crying is the beginning of vocalization and may have implications for the development of speech and language.

"Different investigators have offered various explanations for the first cry emitted by the child. The function of the birth cry is said to be entirely physiological, having to do with the establishment of normal respiration and the oxygenation of the blood. It constitutes the first use of the delicate respiratory mechanism which are to be involved in speech. It is also the first time that child hears the sound of his own voice and, as such has significance for language development". (McCarthy, 1954).

The first cry is said to have other physiological purposes, such as to remove foreign material (Reto), to improve pulmonary capacity in the first days of life (Tang & Hull, 1961), it being a defense mechanism to increase body temperature (Watson & Laurey, 1951).

According to Karelitz (1969), the cry probably starts with a startle reaction created by the first breath. Hopefully, this cry is a good one, if not, a nurse (or) doctor in the delivery room, tries to stimulate the infant to cry. It may be slaping the infant on the foot, back or by one of several resuscitation techniques. The fact that the cry is an essential part of life, alone adds significance to the study of the infant's cry.

"During infancy the child's only mode of communication is cry and we should listen to his vocalization and try to interpret it. When a baby is ill, the parents too are most eager and anxious to have some explanation of his prognosis and possible life long defects. Any method which could provides further enlightment should be thoroughly explored. (Sjuruio, Michelsson, 1976).

The importance of early identification of problem and abnormalities in childhood is increased because of the concept of "critical period" (Lennerberg 1976). If language is a biologically innate function as is presently believed (Lenneberg 1967; Chomsky, 1966) then there is optimum time for its development just as in any biological function.

Early identification is also important. From point of view of early intervention (Bess et al 1976) and Becker (1976) states that in addition to being desirable for child's development, early detection also helps parents to adjust more realistically to the child's problem. As it would make rehabilitation economical.

Attempts have been made for early diagnosis of various problems. The implementation of "high Risk Register" and "infant screening programs" have made early identification possible.

'Screening' as accepted by world health organization is defined as "the presumptive recognition of unrecognized disease or defects by the application of tests, examinations and other procedures which can be applied rapidly" (Roberts 1977). They are not intended to be diagnostic. Persons with positive or suspicious findings must be referred to specialists for diagnosis and necessary treatment (Wilson and Launger 1968).

The concept of High Risk Register (HRR) was introduced to screen the hearing in the new born by Janet Wardy, a Pediatician. Any child who has a history (or) by its physical appearance suggests an abnormality is at risk and such a child is considered as a High Risk Infant. In Wardy's concept, High Risk Register (HRR) is an idea of registering every baby who is at risk, and carrying out systematic follow up every few months, (Downs 1978) for the purpose of early identification.

In the course of time however the HRR has assumed another meaning, that is, it is list of conditions that places the infant at risk (Damis, 1978).

There are a number of High Risk Programs like the National Joint Committee (NJC) on early identification, The Utah state infant H.R. hearing program. The Colorodo Infant Program, etc. In India, a high risk register for hearing loss in children was developed by Ashok, (1981). Questions have been included to collect information regarding the following factors:

1) Family History of hearing loss
2) Consanguinous parentage, primarily involving uncle - niece marriages.
3) History of rashes, fever during pregnancy irrespective of the trimester.
4) Report of Rh blood group incompatibility.
5) Parental concern about their child's hearing.

APGAR Score is a scaling system developed to assess the conditions of the children based on childs behaviour. The APGAR score is designed to determine the physical condition or viability of the new born 60 seconds after birth and it has established that these is a strong association between low scores and neonatal mortality. The scoring method is given in the following table response to a tangential foot slap. In diagnostic value of the cry suggests the potential importance of its role within the APGAR SCORE (Karelitz et al. 1966).

Scoring method in Evaluation condition of new born infant

Sign	Score 0	Score 1	Score 2
1. Heat rate	Absent	slow (100)	100
2. Respiratory effort	Absent	weak cry, hypoventilation	Good strong cry
3. Muscle tone	Limp		Well
4. Reflex irritability (response to skin stimulation to feet)	No Response	Some motion	Cry
5. Colour	Blue Pale	Body pink extremities blue	Completely pink

Two of five parts of APGAR SCORE are concerned with crying. The segment on respiration is a response to environment stimulation i.e., change in the environment stimulation change in the environment. When there is no crying its scored zero. When it is a fair cry, it is scored one, and when it is a good strong cry, it is scored two. The second sign (reflex irritability lists 'cry' in general. The implementation of a HRR requires some one to collect information required for risk categoriztion from various sources like hospital records, interview with (or) written questionnaire given to a mother, physical observation of the child, etc.

According to Karelitz (1960) its possible to identify the age of an infant by listening to the cry of that infant. Further he also states that it would be possible to use this process of identifying age based on cry abnormalities in the child. Studies by Karelitz and Fisichelli (1962, 63) show that there is difference in the latency and threshold of cries of normal and infants with brain damage. The first cry studies were based on auditory analysis alone.

With the development of the sound spectrograph by Porter et al. in 1940's objective analysis of cry sounds has become possible. Since then, many researchers have been doing studies on cry characteristics of normal and abnormal infants. These studies have shown that cry analysis can be helpful in differentiating between normal and abnormal infants and then it will become an additional valuable tool for arriving at the diagnosis and prognosis of new born infants.

The first cry in the infant is said to be very important. The infant is no longer depending on the blood circulation from the mother, and then the oxygen supply to the body must be taken care of by the infant itself. To achieve this, the infant takes the air into the lungs (or) inhalation takes place, which leads to the first cry. A delay in the cry would lead to the lack of oxygen in the body and thus the infant becomes blue. Blue infants are considered to be the high risk infants, showing a history of brain damage. Therefore, whenever there is a delay in the first cry, the cry is elicited by one of the several resuscitation techniques.

Crying is the result of the intense expulsion of air through tightened vocal cords into the pharynx and mouth as a resonating chamber. The character of the cry depends upon the intensity of air expulsion, the tension in the vocal chords and the shape and fixation of the resonating chamber. Since crying is generally a maximal type of response, it reflects the capacity of the nervous system, to be activated and also the ability of the nervous system to inhibit or modulate this activation. The difference in the ability of different nervous systems to respond could be in the peripheral memory receptors, but it seems more complex than that these differences are in the more complex activating systems of the brain, in the brainstem and thalamus. Likewise, the character of the motor response could be due to changes in the peripheral motor control of the expulsion of air, vocal cord tension, and shape and tension in the supraglottal resonators. But it is more likely due to the effects of higher control centers in the brain, that act in modulating or inhibiting fashion on the activating centres.

Borma et al., (1965) suggest that neurological maturity is reflected in stability of laryngeal coordinations and the degree of mobility of vocal tract elements during crying. The source filter theory of speech production provides a theoretical basis for inferring the effects of these vocal apparatus on the infant's cry. According to this theory, the power of the speech sound spectrum (p) at a frequency (F) is the product of two approximately independently controlled factors, the source spectrum (s) and the transfer function (T), that is

$$P(f) = S(f) \times T(f)$$

It may be deduced from the source filter theory of speech production that variability of vocal tract elements which affect the resonance characteristics of vocal tract elements, which affect the resonance characteristics of the transfer functions, is revealed in formant frequency variability in the cry sound spectra. In addition, it may be deduced that variability of vocal cord movement, which affects the source spectrum, is reflected in variability of Fo in the cry spectra.

As the neurological mechanism controlling the vocal apparatus mature, there is increased postural control of the vocal cords and their vocal tract, and as a result decreased variability in the functioning of these organs. Since there is greater variability of vocal apparatus for premature than full term infants, it is hypotesized that the cry spectra of pre mature infants shows greater variability of (a) Fundamental frequency and (b) of formants than those of full term neonates. Thus one might say that a good cry is one that is obtained with a moderate amount of stimulations, has a duration proportional to the degree of stimulation, but is readily terminated by central inhibition, and has some variability in total quality, implying lack of rigidity in the neurologic controlling mechanism. Therefore, detailed knowledge of the characteristic of crying sounds in various conditions may be expected to give considerable information about the nervous system (Parnlec. 1962).

A simplified view of the cry production model was given by Goulb 1979. The model divides cry production into four parts. The first part is the subglottal system that is responsible for developing the pressure below the glottis necessary for driving the vocal fold source. The second part is the sound source located at the larynx. The second source may be described mathematically, in the frequency domain, as either a periodic source or a turbulence noise source. These sources may operate alone, or more frequently, simultaneously. Both acoustic sources originate at the vocal folds. The periodic source results from the vibration of the folds. The turbulence noise is most likely produced by the turbulence created by forcing air through a small opening left by the incomplete closure of the vocal folds. The third source of cry production is the vocal and nasal tracts located above the larynx. This part of the cry production system is an acoustic filter that has a transfer function whose characteristics change with the change in length of the vocal and nasal tracts and the degree of nasal coupling. The fourth part of the cry production system is the radiation characteristic that describes the filtering of the sound between the mouth of the infant and the microphone located some distance away.

The model assumes that muscle control is accomplished within three levels of central nervous system processing, i.e., upper, middle and lower processors. The upper processor is involved in choosing and modulating the state of action of the child. During the neonatal period, this higher processor may be relatively immature, a "conscious" control, and infrequent. As a result, at the stage of maturation, many activities occur in a "reflex like" manner.

It is assumed that all vegetative states such as swallowing, coughing, respiration, bowel movements and crying are within the middle processor. The stimuli that helps the upper processor to choose the appropriate vegetative state include hunger, pain, hypoxemia, or hypercapnia and a full bladder. The neonatal cry is very much like other actions present at birth that are stimulated by survival pressures. The causes of crying are less complex for newborns than those for older infants. As the nervous system matures and the child's environment becomes more complicated, the cry may no longer be assumed to be "reflex like" but may often be the result of volitional activity.

The initiation of each of these previously mentioned vegetative states, in response to a stimulus, must result in the control of a large number of muscles. Most likely there exists some sort of "co ordinative structure" that makes it unnecessary for higher processes to exert control of each muscle within a muscle group.

The newborn cry is envisioned as resembling the same type of process as the vegetative states. Following the cry stimulus, the upper and/or middle processors fcr cry production trigger the lower processor control of the relevant muscle groups.

Each of the three muscle groups important for cry production are controlled independently. Consequently the parameters that each are responsible for are likely to vary independently. Secondly , if one can pinpoint differences in the cry as caused by subglottal (respiratory), glottal (laryngeal) or supraglottal malfunctions, then one will be able to correlate the acoustic abnormality with specific physiological and anatomical abnormalities.

In summary, the mathematical formulation of the acoustic theory of speech production of Fant (1960) can be applied to infant cry production. Output = Source x filter. Thus, it is apparent that there are basically two components to the model of cry production: an acoustical component that specifies how sound is generated in the larynx and a physiological component that specifies how the configuration and movements of the respiratory, laryngeal and. supralaryngeal structures are controlled.

Acoustic component of the model:

Truby and Lind (1965) have described three cry types: Phonation = basic, cry hyperphonation = shift and dysphonation = turbulence.

In phonation, the vocal folds vibratfully at an Fo range of approximately 250-700 Hz. Hyperphonation results from a 'falsetlo' like vibration pattern of the vocal folds with an Fo range of about 100-2000 Hz. Finally dysphonation contains both a periodic and aperiodic sound source and occurs when turbulence noise is generated at the vocal cords. These three modes of vibration can occur during the expiratory cry.

For a vocal tract length of about of about 8 cm. (Goldstein 1979) and for a roughly uniform vocal tract cross sectional area, acoustic theory predicts that formants at about 1100 Hz or 3000 Hz. If there is substantial veopharyageal opening, then theoritical analysis predicts additional spectral peak in the frequency range of 2-3 Khz. If the pharyngeal region is narrowed, then acoustic theory predicts an upward shift of the formants. The fundamental frequency of vocal fold vibration and indeed the mode of operation of the vocal folds depend upon the subglottal pressure and the adjustment of the instrinsic laryngeal musculature. Increased subglottal pressure would be expected to result in a higher Fo; However Fo may also influenced by contraction of the cricothyroid muscle (Vanden Berg, 1965).

A cry sequence for an infant usually consists of series of relatively long expiratory cries separated by brief inspiratory intervals. It is not unreasonable to expect that the durations of the units within the cry sequence and the time intervals between cry which are dependent on the state of the infant's respiratory system. For example, a diminished vital capacity resulting in a relatively small tidal volume, would be expected to produce short and lower intensity cry units (Golub, 1980).

PHYSIOLOGICAL COMPONENT OF THE MODEL:

The physiological component of the model is based on the hypothesis that newborns tend to control the tension in their muscles in a noncontinous fashion. One can explain three cry types described spectrographically by Truby and Lind (1965). Large differences in the acoustics between these three cry types can be explained by changes in the relative tensions (higher (or) low) of just ten (or) three laryngeal muscles (Golus, 1979). These would be analogs to register shifts in adult speech (Van den Berz, Evidence from measurements made on 1965). The acoustics and subglottal pressure during the cry (Trub and Lind, 1965) indicates that tensions of the larger respiratory muscles do indeed change some what continuously during the expiratory phase. In case of these larger muscles, the continuous, relatively slow tension changes probably occur due to peripheral state changes of the muscles rather than continuous variation in the control of these muscles. The most important of these states changes can be described by the length tension loading aspects of particular muscles of the system. The resulting muscle tensions are not only a function of higher level control, which is probably quantal in nature, but also of the particular length loading characteristics of the muscles at the onset of the control.

The muscle control hypotheses helps us to direct the choice of acoustical features that will accurately reflect the physiology of the infant. For example, three cry types described by Trubz and Lind (1965), representing different modes of sound production analogs to register shifts in adult speaker makes it clear that the acoustical features are measures which will vary with the particular mode of sound production. Infact, a different range of normal acoustical features could be defined for each mode of sound production. This implies that meaningful cry analysis requires an assessment of what mode of sound production was used at the time of the recordings. Infact, previous spectrographic data (Trubz & Lind, 1965) have shown that the maximum Fo in phonation rarely exceeds 550 to 600 Hz; However, a maximum Fo of 1500 to 1600 Hz is not unusual in hyperphonation. In summary, the model of cry production can provide guidance for the selection of the acoustical features that are most likely to reflect the anatomy and physiology of the infant accurately.

FACTORS THAT INFLUENCE CRY PERFORMANCE:

Infant cry is a product of the respiratory phonatory system whose output has been shown to have high degree of variability with regard to pitch and intensity. The respiratory system which is undergoing rapid maturational changes account for much of the variability. The breathing rate of an infant varies as a function of age, health, general activity and the presence of vocalization. Initially as Fiscichelli et al (1966) have pointed out there is inspiratory voicing in the nenonatal cry. This inspiratory sound often makes it difficult to identify an expiratory cycle. As the infant natures, these vocalized inspiratory periods become more like sobs and virtually all cry becomes expiratory. By age of 1 year, infants acquire the quick inspiratory and long expiratory phases of respiration associated with adult speech and breathing. Shortly after birth, the infant adds to the abdominal movement of early cry by involving the thorax. After six months rib cage movements and the activity of the coastal cartilages allow for deeper breathing, leading to the reduced rates of ventilation.

Cry behavior varies according to the cry evoking events or stimuli. The birth cry which is unique sequence of vocal behaviors made within minutes of birth, may be partially pain related as well as hunger and environmentally related. The infant is taken from a dark, warm, quiet environment with a nutritional source and is subjected to noise and noxious stimuli. This results in a cry that has a short repetitive cycle and relatively high average fundamental frequency, presumably due to the high laryngeal position (Lieberman, Harris, Wolff & Russell, 1971; Trubz, Bosma, Lind, 1965). Thus the birth cry is primarily a response to the infant's external stimulus. Further it serves to assist in the cardiorespiratory organization in the new environment.

Following the birth cry, the infant cries for several possible reasons: pain, hunger, discomfort (or) shock. Early work by Sherman (1927) also considered anger, fear, however these states are difficult to verify. Murry, Gracco and Gracco (1979) reported on one infant who produced cries prior to feeding (hunger) & prior to having her diaper changed (discomfort). At 2 weeks of age, hunger cries were characterized by a higher fundamental frequency of phonation (Fo), greater Fo range, longer mean cry durations, a larger proportion of phonation to silence and a more complex melodic contour than the discomfort cry. The discomfort cries with their limited Fo range & higher incidence of a flat melody were interperted as reflecting the constraint or physiological tension associated with discomfort.

Most of the literature describes pain and hunger cries as the two cry type used in the study of infant cry behavior. A third type startle cry has been used in several recent investigations. Pain cry is considered as cry from suddenly inflicting a painful stimulus to the infant. Muller, Mollien & Murphy (1974) stung the base of the foot with a rubber band. Others have recorded the cry coincident with taking a blood sample. Still others have used a pin prick on the heel of the foot to elicit the pain cry.

The hunger cry is usually defined as the cry produced by withholding food from the infant at the normal feeding time. In some instances, feeding is begun and then stopped, resulting in what is operationally defined as a hunger cry. The startle cry has been elicited in a number of ways, from a loud clap near the infant's head to suddenly dropping the child towards a table top.

Prior to the controlled investigations in 1960's, no clear evidence was available to indicate the "presence of physical differences or any communicative functions of the various cry types. In 1963, Wasz Hockert, Valanne, Vuoren Koski, Michelsson & Solvijarri (1963) reported oh the acoustic patterns of birth, pain and hunger cries using sound spectrography. They described the rising or falling patterns in the birth cry but only qualitative differences between the pain and hunger cries. Sedlackova (1964) noted the birth cry to be a high frequency signal. Murry, Amundson & Hollien (1977) systematically examined the frequency characteristics of pain, hunger and startle cries of 4 male and 4 female infants. For all three types of cries the males produced a higher mean Fo than females. The cries were not only differentiated on the basis of sex but also according to cry type. Pain cries resulted in the highest Fo, followed by the hunger cry; the startile cries had the lowest mean Fo. However, the difference in Fo were not statistically significant and each infant had a large standard derivation for at least one cry type. The consistent finding of higher Fo in males for all cry types verifies a trend reported by sheppard and Lane (1968); namely that male infants have a higher Fo than females and also speculation by Hollien (1980) that male voice fundamental frequency is higher than the female voice during first 6 years of life.

Majority of studies of cry duration and cry intensity are based on data derived from pain cry stimuli. More information regarding trends in age, sex and cry types (especially pain and hunger) is available with each new generation of investigators.

The acoustic patterns of cries have given rise to numerous investigations of auditor's perception of these events. The notion of cry as a meaningful mode of communication stems from early perceptual studies of infant vocalizations. In 1927, Sherman attempted to elicit distinctive emotional response from neonates using four stimuli; restraint of the head, pricking with a needle, with holding feeding and suddenly dropping towards a table top. She found that both trained subjects (nurses, medical students and graduate psychology students) and untrained observers (college Freshman) were unable to match correctly the emotional responses with the cry evoking stimuli. Although Sherman argued that the nature of the discomfort could not be distinguished on the basis of the cry. The techniques for testing the two observer groups did not allow for separtion of the visual and auditory components of the infant's cry responses nor were their judgements based solely on the auditory perception of the cry sounds. Wasz-Hockert, Partanen, Vuorenkoski, Valance & Michelson 91964) tested the notion that different types of infant vocalization are perceptually distinguishable. Recordings of vocalizations 'typical' to the situation of birth, pain, hunger and pleasure were obtained from normal neonates. Eighty nurses who were trained in the care of crying children, listened to the randomized cry recordings and were able to identify the type of vocalization 67% of the time. In a follow up study, Wasz - Hockert et al (1964) used the same experimental method to examine the effect of training or the ability of the listener to identify the cry evoking stimulus. They found that the trained listeners were able to identify the types of cry evoking stimuli better than the untrained listeners.

Muller etal (1974) reported or the perceptual response of mothers to the cries of their children. In a carefully controlled experimental protocol, they elicited three types of cry pain, hunger and startle from four male and four male infants age three to five months. All the children were healthy and the samples were obtained in a quiet environment. After all recordings were made, first and third 15 second segments of each of the 24 recordings (eight infants by three stimulus condition) were extracted, randomized, and presented to two group of listeners. Group A consisted of the mothers of eight infants recorded in the study. They were asked to indicate on their answer sheets whether the stimuli that originally evoked the cry were of pain (P) hunger (h) (or) stratle (S), and whether or not the sample was from their infant. Group B consisted of ten mothers of children whose ages were comparable with the infants recorded in the study but who had no previous contact with eight subjects. The results indicated that, some of the hunger cry samples were correctly identified as hunger cries, a significant number of times by both groups of listeners and a number of other samples also were, incorrectly, identified as hunger cries a

significant percentage of time. Therefore it must be concluded that mothers incorrectly perceived an excessive number of samples as hunger cries and that those hunger samples that were correctly identified merely reflect this general bias. These results were similar for the samples of mothers judging only their own infant as well as for judging all infants. These results support the contention that the acoustic characteristics of the cries of normal infants carry little perceptual information to the mother with respect to the cry evoking stimulation (Murry, Moitdalgard & Gracco 1983). It might be hypothesized, therefore that within the normal situation, the cry generally acts simply to alert the mother and that any of her suppositions concerning the situations that evoked the cry behavior must be based upon additional cues from the environment (or) the context of the situation.

In further studies (Murry, Hollien & Muller 1975) it was observed that mothers recognized their own children simply on the basis of a 15 second cry, despite the fact that they could not recognize the cry type. When it came to judging the sex of criers, mothers had difficulties with the task, except when judging their own children. After acoustically analyzing the cries, the investigators (Murry etal, 1977) concluded that the perceptual cues relating the fundamental frequency and vocal tract that are utilized in judging the sex of adult voices are not evident in the voices of infants. Moreover, the finding of higher Fo values in males from infants to age 6 would be expected to lead judges to erroneous conclusions about sex, because Fo is so extensively used in perceptual judgement of speaker's sex (Sing, Murry, 1978).

TECHNICAL & METHODOLOGICAL CONSIDERATIONS - STUDIES OF INFANT CRY:

Infant cry can be considered in terms of its signal and sign properties. As signal, the sound is a complex wave form, requiring sosphicated acoustical devices for analysis. To avoid, the problem of signal/noise interactions the recording of crying is done at its source, that is, the infant's mouth. This approach skirts the perceptual issue, namely, what is the sound when it reaches the listener? Ignoring the element of time, it's possible to describe certain features associated with the intrusive, alerting quality of these recorded sounds, specifically their intensity (83 - 85 d3) and the prominence of octave harmonics (Ostwald, 1972). Sound spectrography has the advantage of preserving the temporal configuration. This method also gives a farily reliable "picture" of certain events that cannot be described by listeners, that is, microsegments containing shifts, biphonations, and the like occurring subliminally probably but still adding to the total "impact" the cry makes on the listener. In this respect, spectrography represents a most important technical innovation. However, when large samples have to be analyzed, spectrography becomes an overly time consuming procedure, and there is also some loss of accuracy in the temporal realm resulting from discontinuities between adjacent spectrograms. For this reason, Poulter, 1968 has used a continous spectrography (a Ragscan appartus designed at the Stan ford Research Institute in Menloo park, California). In one study, when it was necessary to process many cries produced by craniopages twins, Peltznan et al (1970) have relied on computer —averaged spectra to compare the two babies. Several cry studies using high speed digital computation have appeared since then (Lester & Zeskind, 1982; Tenold, Crowell, Jones, Daniel, M.C. Pherson, and Popper,

1974) and it seems reasonable to assumed that future research will begin to explicit automated methods more and more.

In terms of data collection, crucial decisions have to be made about the sign properties of infant sounds, under conditions of continuous bedside monitoring (Vuorenkoski, Lind, Wasz - Hockert, & Partaken, 1971). If spontaneous vocalizations are to be included in the analysis, it becomes difficult to know when to label a sound a cry as distinct from a noncry. And how is one to define the conditions causing a cry ? Gastric intubation (to measure contractile events presumably related to hunger), skin electrodes (to measure EEG) or (EMG correlates), and other required instruments tend to be seen as invasive and restrictive methods; today they are often unacceptable in terms of the etnics of human experimentation. To inflict pain deliberately is another objectionable technique, especially when the subjects cannot give informed consent. Efforts have been made to minimize these objections by recording the cries produced by so called routine procedures for example, blood sampling or circumcision. But such stimuli tend to be excessive and can produce exaggerated vocal responses. Also, the presence of ancillary personnel -lab technicians, nurses and the like - in the recording area adds unwanted noise and makes for a less than ideal experimental environment. In studies usually three cry types appear to emerge with a definable construct - birth cry, pain cry and hunger cry. Although the hunger cry may actually embody other cry characteristics such as distress, discomfort, and irritability, feeding tends to eliminate the cry behavior and may therefore be operationally defined the hunger cry. Future investigations of cry will require more specific definition of the cry types and move rigorous control of the events leading to the cry.

TECHNIQUES OF CRY ANALYSIS:

The infant cry has interested researchers of different disciplines for a long time and several methods have been utilized for cry analysis. Cry studies of infants have been done by auditory analysis, with musical notes, phonetic transcription, volume unit graphs and analysis by using electrolaryngograph, spectrograph and computer analysis.

AUDITORY ANALYSIS:

The most readily available means for cry analysis is the human ear. Over years, various technological advances have increased our ability to assess the infant cry by listening. One of the first reports of the acoustic structure of infant cries was published in 1838 by William Gardiner. He described the cries calls of both humans and animals by means of musical signs. According to Gardiner, the tones of infant crying generally are between the notes of A & E in the middle of the piano key board. The initial expiratory component is usually the most prominent feature of the cry; it lasts about a second on an average and has an up and down melodic patterns. The inspiratory component of the cry is much shorter.

Flatau & Gutzmann (1906) used a graphophone to record infant vocalizations. They listened to the cry recordings of 30 neonates and noted three infants with high pitched phonations. In 1936, Levis used the international phonetic Alphabet (IPA) for the first time in an attempt to describe infant vocalizations. Fairbanks (1942) listened to gramophone records to study the frequency characteristics of the "hunger wails" of one infant over a period of 9 months.

Wasz-Hockert, Partanen, Vuroem Koski, Valanne (1964) have found from tape recordings of hunger, pain, pleasure and birth cries can be identified auditorily. Valanne etal (1967) found that mothers can recognize the vocalization of their own infants. This finding was supported by the work of Fromby (1967). Massengill (1968) found that speech clinicians were not able to recognize grade of nasality (or) type of crying of infants with cleft palate.

Partanen, Wasz - Hockert, Vuorenkiki, Theorell, Valanne & Line (1967) demonstrated that the pain cries of healthy infants could be differentiated from cries of sick babies with one of the following diseases: Neonatal asphyxia neonatal brain damage, neonatal hyperbilirubinenia and Down's syndrome. It was shown that after a training period of approximately two hours 82 pediatricians could diagnose normal and pathological cries very accurately, differentially diagnose specific pathology, some what less accurately.

Hollien, Muller, Murphy (1974) studied the ability of 18 mothers to perceptually differentiate cry samples elicited by 3 different stimulus conditions - Hunger, pain, and auditory stimulation. In some instances, the mothers were evaluating cries produced by infants with whom they were unfamiliar and in other cases they judged cries produced by their own infants. Results indicated that 18 mothers were unable to successfully match the cry samples with three cry evoking situations. The investigators hypothesize that within normal home situation, the cry generally acts simply to alert the mother and that any of her suppositions concerning the situation that evoked the crying behaviour must be based upon additional environmental cues.

Murry, Amundson and Hollien 91977) noticed that an infant's sex could not be reliably identified on auditory basis. Auditory differences between the crying of sick infants and healthy ones have often been recognized by perdiatricians. Illingworth (1955) states that, "a clinician recognize the hoarse, gruff cry of cretinism, the hoarse cry of laryngitis, cerebral irritability, the sweating cry of pneumonia, the feeble cry of amytonia (or) a severely debilitated infant, the whimper of the seriously ill child" .

Partanen etal 91976) found that audible differences were recognizable when the cries of healthy newborn infants and those which asphyxia-brain damage, jaundice/Down's syndrome were compared by 45 pediatricians 137 medical students. The test tape included 20 pain cry signals representing eight normal and three cries each from other groups. A few months training improved the ability of medical students to recognize cry types. The studies have demonstrated that medical information can be obtained from listening to cries. This method of analysis is readily available and can be improved with experience, training. However it is clear that auditory analysis provides only a fraction of information contained in the cry signal, that more sophicated techniques might give more significant diagnostic information.

TIME DOMAIN ANALYSIS:

Time domain information is obtained from devices that groph sound magnitude versus time on a paper strip chart. Fisichelli & Karelitz (1963), Fischeelli, Karelitz, Eichbauer & Rosenfield (1961) & Karelitz (1962) used such a device to examine infant cries. They found that infants with different brain damage required a greater stimulus to produce 1 minute of crying (1962) and that near latency period between pain stimulus and onset of crying was significantly longer for abnormal infants (2.6sec) compared to healthy infants (1.6 sec) (1963).

A direct writing oscilograph was a time domain device used by Lind, Wasz-Hockert, Vuroem Koski and valanne (1965) to study the time course of the duration and latencies of different kinds of crying. They found that the initial phonation of a cry records are more irregular than those that appear once the infant is fully aroused. After this arousal, a gradual reduction in time and intensity of the cry units occur until the baby stops crying.

Wolff (1967, 69) measured inspiratory as well as expiratory phonation and revealed duration differences between "hungry, mad pain produced, and teased crying" in four day old infants. His data also indicated that in pain produced cries, the cry units (one expiratory phonation) are longer in the beginning of the cry record than at the end.

The preceding studies illustrate that useful (though limited) information can be obtained utilizing time domain instruments. This technique has the advantage of being relatively easy to operate and it is inexpensive, reliable and easy to inspect visually. However there are also many problems with this method of analysis. There is signal distortion due to pen inertia and paper speed variation that results in poor frequency response. Manual measurement of feature is open to human error and is rather tedious process. Finally the magnitude information shown is in reality an average measurement over a short time interval. This interval is fixed in writing of the apparatus in the inflexible and liable to lose important information.

FREQUENCY DOMAIN ANALYSIS:

Devices performing frequency domain analysis allow one to obtain a course representation of the frequency spectrum characteristics of a sound. They utilize a bank of band pass filters. These filters allow only input of a specified frequency, range, measure the average magnitude in that range and give a visual display of the relative magnitude. One can then compare the relative magnitude of a series of frequency range. The band pass filters cure either one third or, one half of an octave in width.

Ostwald, Freeman, & Kurtz (1962) used the half octave band analyzing to examine the cries from 32 twins. They determined that the variability in pitch measurements and temporal characteristics between the cries of twin could be explained by differences in "weight, size, physical development and vigor of the children recorded". Ostwald etal concluded that it was the other factors that determined the characteristic of the cries and that heredity did not play a major role. Later Ostwald (1963) used half octave analysis to analyze the cry of normal neonate and found the fundamental frequency to be between 425 and 600 Hz. As implied by the name, these devices only give information about the relative magnitude of various frequency ranges. They do not give timing information. In addition, the band pass filters use a relatively easy, inflexible bandwidth. This makes the frequency information obtained of limited value. However an illustrated by the work of Ostwald, some useful information is obtained with this method of sound analysis.

IV SPECTROGRAPHIC ANALYSIS:

The sound spectrograph produces a permanent visual record showing the distribution of energy in both frequency and time. It was originally developed at Bell Laboratories in the late 1940s. Its main goal was to aid the deaf by presenting a visual display of speech. It didn't achieve this goal because of the complexity of the speech signal as well as the limitations of the spectrograph itself. However since it was presented in 1946, it has been a very useful important device in many areas of signal processing. These areas include adult speech, animal, bird sounds, music and infant cries.

Over the past 20 years, most studies of the infant cry have utilized the sound spectrogram. Scandinavian research headed by Wask Hockert and Lind has particularly advanced the understanding of infant cry. They have defined spectrographically based cry parameters that can be grouped into two general categories: duration features and fundamental frequency features. A short description of these spectrographic features are as follows:

a) Duration features:

1) Latency period: The time between the pain stimulus applied to the child and the onset of cry sound. The onset of crying was defined as the first phonation lasting more than 0.5 seconds.

2. Duration: This feature is a measure of the time from the onset of the cry to the end of the signal and consist of the total vocalization occurring during a single inspiration (or) expiration. The boundaries were determined by the point on the spectrogram where sound "seems" to end.

3) Second pause: The time interval between end of the signal and following inspiration.

b) Fundamental frequency features:

* Maximum pitch: The highest measurable point of the fundamental frequency seen on the spectrogram.

* Minimum pitch: The lowest measure point in the Fo contour seen on the spectrogram.

* Pitch of shift: Frequency after a rapid increase in the Fo seen on the spectrogram.

* Glottal roll/vocal fry: Unperiodic phonation of the vocal folds usually occurring at the end of an expiratory phonation when the signal becomes very weak Fo becomes very low.

* Vibrato: Defined to occur when there are at least four rapid up and down movements of Fo.

* Melody type: Either falling, rising/falling, rising, falling/rising or flat.

* Continuity: A measure of whether cry was entirely voiced, partly voiced, (or) voice less.

* Double harmonic break: A simultaneous parallel series of harmonics in between the harmonics of the fundamental frequency.

* Biphonation: As apparent double series of harmonics of two fundamental frequencies unlike double harmonic break, these two series seem to be independent of each other.

* Gliding: A very rapid up and down movement of Fo usually of short duration.

* Noise concentration: High energy peak at 2000 - 3000 Hz found both in voiced and voiceless signals, this attribute is clearly audible.

* Furcation: Term used to devote a 'split' in Fo where a relatively strong cry signal suddenly breaks into a series of weaker ones, each one of which has its own Fo contour. It is seen mainly in pathological cries.

* Glottal plosive: Sudden release of pressure at vocal folds producing an impulsive expiratiory sound.

Many investigators have examined the correlation between abnormal ranges of spectrographically obtained cry features and particular medical problems.

Spectrographic studies were carried out for infants with oropharyngeal anamolies (Line et al 1965; Massengill 1968; Michelsson 1975); asphyxia neonatorum (Michelsson, 1971; Michelsson etal, 1975); asphyxia neonatrum. (Michelsson 197 ; Michelsson etal 1977; Wasz Hockrt, Lind, Vuroenkoski, Partanen, V.Valance, 1968) symptomless low birth weight (Michelsson, 1971); Herpes encephalities and congential hypothyrodism (Michelson, Sirrio, 1975, 1976); Hyperbilirubnemia (Wasz-hockert etal, 1971), malnourished infants (lester 1976); Genetic defects (Fisichelli, Coxe, Rosenfield, Haber, Davis, Kavelitz, 1966; Lind, 1965; Lind etal, 1970; Vuorenkoski et al, 1966; Wasz Hockert etal 1968); Sudden death syndrome (Collon, Steinschneider, 1981; Stark & Nathanson, 1972); & mixed syndromes (Ostwald, Phipps, & Cox, 1968; Wasz hockert etal, 1968).

Obviously, the spectrogram has been a useful tool for the advancement of understanding infant cry analysis. It is relatively inexpensive and is a good way to 'visualize' acoustic signals. However, it has several limitations. First, there are physical limitation of the analysis. The spectrogram has a poor dynamic range, often inadequate frequency resolution. In addition, the spectrogram requies visual inspection of the output for interpretation.

Extracting acoustical information spectrographically is a long and tedious process that require much expertise. As a result, it's not possible to analyze a large sample of cries quickly and accurately.

5. COMPUTER BASED SIGNAL PROCESSING:

Computer analysis allows more accurate determination of the acoustical information and extractions of information that would otherwise unobtainable.

The analysis procedure consists of five major steps:

1) Recording of the cry

2) Obtaining the parameters of fundamental frequency, formants & amplitude Vs. time.

3) Sampling the complex Fo contours in order to facilitate the development of Fo features.

4) Developing a number, of features from the parameters & samples by procedures that include averaging within cry modes & calculation of probability of being in any mode and any point in the cry.

5) Conglomerating relevant features into and set of "diagnostic tests".

The requirement for tape recording system include a relatively flat (3dB 100 - 1500 Hz) frequency response, a dynamic range of 40 to 45 dB and a signal to noise ratio of approximately 20 to 250 Hz.

The recordings are processed to obtain the parameters of amplitude, fundamental frequency formant frequencies. Region in which the three laryngeal modes (phonation, hyperphonation & dysphonation) occur are marked as well as the occurrence of glottal stops and inspiration phonation.

From the amplitude contours, formant tracts, and fundamental frequency contours, features are extracted at appropriate items in order to allow reconstruction of the contour or tract with a minimum of lost information. Timing and amplitude data are obtained from each of the first eight cry units and detailed formant frequency and Fo data are extracted from first two cries in each sequence. These features specify certain attribute of the Fo contour for phonation, for hyperphonation, certain attributes of the formant contours and classification of phonation types in each cry and so forth. The final analysis stage utilizes 80 features to determine the outcome of specific cry tests. This stage essentially entails the conglomeration of those features that best represent the specific test of interest. One can then assess each feature individually (or) group of features into appropriate. Grouping of feature into test is based on model of cry production.

A computer baaed signal processing system is utilized for all data extraction. This system allows complete analysis of a cry in 5 to 10 minutes and is entirely automatic. The computer is able to control the taperecorder, so that can merely insert a tape, tell the computer what time to start the analysis and then return late to examine the results.

CRY IN HEALTHY FULL TERM INFANTS

Analysis of pain cries from more that 330 healthy new born infanta was done by Michelsson, 1971; Wasz Hockertal et al, 1963, 1964, 1968). Study done by Thoden, Koinisto (1980) dealt with prospective analysis of cries of 38 infants from birth to 6 months of age and analyzed the first, second, third phonation after the pain stimulus. In all pain cry studies done, the mean maximum pitch of fundamental frequency without shift has been about 650 Hz and the mean minimum pitch about 400 Hz. In 80% of the samples, pain cry had a falling or rising/falling melody type with a stable pitch and a duration of approximately 2.5 sec. Shifts with higher pitch occurred roughly in every third cry. The mean maximum pitch of shift was about 1200 Hz. The mean maximum pitch of whole cry was 800 Hz when the maximum pitch had been measured from highest part of either the main fundamental frequency or shift. The signals were voiced and continuous in about two thirds of the cries. The occurence of glottal roll was quite common, mainly at the end of phonation. Vibrato occassionally percedded the glottal roll part. Biphonation, glide, furcation and noise concentrations were extremely rare in normal infant cries (Michelsson 1971; Thoden & Koivisto 1980; Wasz - Hockert et al 1968). In order to investigate possible standardized differences the cry characteristics of second and third cry signals in pain induced cries, Thoden & Koivisto (1980) did a study on cries of 38 children. They found that 3 first cry signals after the pinch did not differ much from each other. There was no significant difference in the maximum and minimum pitch of the fundamental frequency in the three signals analyzed. Shifts were however more often in the first cry signals even if the differences were not statistically significant. Because of more frequent occurrence of shifts, the maximum pitch, including shift was some what higher in the first cry signal. The second and third signals were significantly shorter and more often continuous than the first signal. Glottal rol and vibrato were more common in the first signal.

The variation in the durational features in normal newborn infants is quite large. According to different authors, the latency period is from 0.6 to 3.6 seconds. This variation is attributed to measuring techniques and the infants wakefulness. But it may also be due to the fact that the latency period is not quite uniform in healthy neonates. The first latency is often longer than the latency of immediately repeated stimulation. Various reports have given different duration of phonation depending on the analyzing techniques used. The average is reported from 1.1 to 2.8 secs. (Siruio & Michelsson, 1976).

Another characteristic response of the normal infant, a few days older has been reported by Karelitz, Fisichelli (1969). When the rubber band snap was used as a means of stimulation to elicit the pain cry, there was a startle reaction formed by a period of breath holding. The arms and hands are extended, his facial expression is that of fright and loud burst of crying is followed by several bursts which are similar to the first. As the child continues to cry, the bursts taper off to a stop. In the case of an older child, he might also sob for some time. Sobbing is not observed in severely brain damaged infants.

Birth, hunger and pleasure cries were analyzed by Wasz-Hockert et al (1968). In 148 hunger cries the mean maximum pitch was 550 Hz. and mean minimum pitch 390 Hz. The shift occurred in only 2% of the cries. The melody type was falling or rising/falling in 80%. Glottal roll occurred in 24%. In 77 first birth cries, the mean maximum pitch was 550 Hz. and mean minimum pitch 450 Hzr. Shifts occurred in 18%. The cries were of shorter duration, mean 1.1. sec. Pleasure cries had a mean maximum pitch of 650 Hz and mean minimum pitch of 360 Hz; shifts were seen in 19% glottal roll in 26%, flat signals were more common, occurring 46% of time.

Thoden & Koivisto (1980) made a prospective study of cries of infants at 1 & 5 days of age and at 3 & 6 months. The only significant difference in first cry signals at age 1 day, 5 days, 3 months and 6 months were that the signals were less often continuous at age of 3 months. And that vibrato was less common at the age of 6 months. Results indicate that there are few changes in cry characteristics from one day of life up to the age of six months. The results showed however there were difference in cry characteristics, infants. It has been found that it is not only the pitch but also other cry characteristics that change when child is sick and these changes are especially common in diseases in which the central nervous system is affected.

CRY IN NEW BORN LOW BIRTH WEIGHT INFANTS:

Michelsson (1971) analyzed samples of 105 symptomless low birth weight infants. Results showed that there was no difference in the cry of low birth weight infants and 50 healthy full term infants with low birth weights. The mean of maximum fundamental frequency in the infants with low birth weight was 640 Hz. The premature infants were divided into 2 groups. Those born at 35-37 gestational weeks and those born at 34 gestational week or earlier. Results showed that the younger infants cried with a higher pitch. The fundamental frequency was highest in the youngest prematures with a mean of maximum pitch being 1360 Hz and a mean of minimum pitch being 590 Hz. The dominating melody type in all premature infants was falling or, rising/falling similar to the controls. Biphonation and gliding occurred in the cries of prematured 5 - 14% of the time. No significant changes were seen in the continuity and voicing of signals and also in the occurrence of double harmonic break or in the second pause. As the premature infants grew older, its cry become similar to that of a healthy child born at full term.

Ternold et al (1974) found a median fundamental frequency of 752 Hz for 5 premature infants and 518 Hz for 9 full term infants. Lester and Zerklind (1978) found that the cries of full term but underweight infant had a shorter duration (2.0 sec) and a higher fundamental frequency (740 Hz) than babies of normal birth weight (4.9 secs and 467 Hz. respectively.).

CRY IN NEWBORN INFANTS WITH ASPHYXIA:

Michelsson (1971) collected cries from 250 asphyxiated infants during the first 3 days of life. All infants were bom with APGAR score of 7 or less at 1 or 5 minutes of age. The children were divided into groups depending upon whether the child suffered from respiratory distress (Peripheral asphyxia) or had neurological symptoms in the new born period (central asphyxia). The cry characteristics were compared to the crying of 50 healthy full term and 75 premature infants depending on whether the neonate with asphyxia was full time/premature. In both, gestational age groups, cry was abnormal in 125 children with central asphyxia and in 80 children with peripheral asphyxia. The cry was, however different in both groups from abnormal infants. The mean maximum pitch including shift was 1460 Hz. in full term neonates with central asphyxia, 1000 Hz in peripheral asphyxia and 650 Hz in controls (Michelsson & Wasz - Hockert, 1980). Prematures with central asphyxia had a mean maximum pitch of 1950 Hz. including shift, the mean in peripheral asphyxia was 1610 Hz. and in symptomless prematures, 1520 Hz.

Michelsson (1971) showed that biphonation occurred more than 20%, glide in more than 10% of samples with asphyxia. Rising and falling/rising types of melody occurred in more than 30% of the signals. These changes in the cry characteristics were more marked, the more severely the newborn had suffered from asphyxia.

Michelsson (1971) found that if the cries became normal in few days after asphyxia the child was more likely to recover without neurological sequelae than if the cry characteristics remind abnormal during the hospitalization period. The prognostic value of cry analysis in asphyxia was confirmed in a follow up study by Michelsson et al (1977). The results showed that infants who at later check up were found to be neurologically damaged had more abnormal cries in the newborn period.

Syutkina, Michelsson and Sirvio (1982) from an animal studies experimentally confirmed that asphyxia produce changes in the sounds produced. The study analyzed the utterance of wistar rats in which asphyxic was experimentally caused by clamping the umbilical cord 2 to 4 days birth. Antenatal hypoxia was found to produce a significant increase of maximum pitch and decrease in duration of phonation. The mean maximum pitch was 4140 Hz in 61 pain induced utterance of asphyxiated rats and 2890 Hz in 34 utterances of control rats.

CRY IN CLEFT PALATE INFANTS:

Messengill (1969) investigated to determine whether the speech clinicians who have worked with cleft palate children could differentiate between cleft palate and cleft lip babies from the recordings of their cries. He also investigated to see if there was significant correlation between length of cry and the judged nasality of the cry. 30 infants in the age range of 1-24 months were taken. The results indicated that judges were not able to find any differences in nasality between the cries of babies with cleft palate only, with cleft lip only and babies with both. Correlation between length of the cry print and judged nasality of the cry; and the age of the child and nasality of the cry were not statistically significant. Generally, the longer cry prints were from the older children.

Sound spectographic analysis of infants with cleft palate was reported by Michelsson et al (1975); 52 cries from 13 infants with cleft palate were analyzed. When compared to cries of healthy neonates of the same age, no differences were observed with respect to fundamental frequency. The mean maximum pitch was 710 Hz, the mean minimum pitch was 360 Hz. The melody type was falling or rising/falling in 88% of the cry samples glide occurred in 10% of cleft palate infants. Biphonation was not seen. Several cry characteristics connected with disturbance of CMS were not seen in the cries of cleft palate infants. In studies by

Raes et al (1980), Raes, Michelsson, Dehaeu, and Despontiv (1982) these results were confirmed.

CRY IN INFANTS WITH HEARING IMPAIRMENT:

Collins (1954) in a symposium on the deaf child, has written that deaf babies coo and gurgle in a normal fashion and that from 9-18 months this appear to be developing speech, saying 'mumum', 'dada' but that no further progress in speech is then made. Taperecordings of infants of congentially deaf parents and of normal parents showed no difference. The vocalization, cooing and crying were identical and were regarded as developmental.

A comparative study of prelinguistic vocalization of deaf and normal hearing was done using sound spectrographic analysis by Stanley (1976). The infants ranged in age from 17-24 weeks. A significantly greater number of identifiable stops and greater voice lag time were found in the deaf infants vocalization patterns.

CRY IN CHROMOSOMAL ABNORMALITIES:

Study on cries of infants with chromosomal abnormalities Vuorenkaski et al (1966) analyzed the cries of infants with deletion of chromosome No. 5, the cri-du-chat syndrome. A general pitch of 860 Hz in 44 cries of 8 children was noted. Additionally it was found that a flat melody type occurred in 36% and rising melody type in 23% of the samples. Michelsson et al (1980) found approximately the same value of the fundamental frequency in two infanta with cri-du-chat syndrome. Flat melody types were common. Luchsinger, Dubois, Vassella, Doss, Gloor, and Wiesmann (1967) and Bauer (1968) have also found that children with cri-du-chat syndrome had cries with pitch of 1000 Hz.

Michelson et al (1980) had analyzed 135 cries of 14 infants aged 0-7 months, who exhibited various chromosomal abnormalities, except Down's syndrome. Two of the infants had the 'cri-du-chat" syndrome, two deletion of chromosome, 3-13 trisomy, 3-18 trisomy and one case each of abnormalities of chromosome 1, 2, 8, and 20.

The duration of the cries in the chromosomally abnormal infants had a wide range from 0.3 to 18.7 secs. The maximum and minimum pitch were significantly higher in case with short arm, deletion of chromosome 4 or 5 in the case with partial trisomy 1, and in one case with trisomy 18. Significantly lower maximum and minimum pitch were noted in a case with extra chromosome material at the distal end of chromosome 1, a lower maximum pitch in one case of trisomy 18, a lower minimum pitch in one case with trisomy 13 and another with trisomy 18. The cry in the cri-du-chat' syndrome differed from the cries of other chromosomal abnormalities as it was more high pitched and had a flat monotonous melody type. Shifts occurred in almost every second cry. Shift and flat melody type was less common in the cries of infants with anomaly of chromosome 4. The lack of shifts and the frequent occurrence of glottal roll in 13 and 18 trisomy accentuated the hoarse low pitched cry in these infants. The dominating melody type in 18 trisomy was falling/rising - falling and more flats signals occurred than in the controls. In 13 trisomy, signals with flat melody type were also increased, when compared with the controls.

It was also found that the pitch characteristics in chromosomally abnormal infanta were different from those in infants with other diseases affecting the brain, such as asphyxia, hyper bilirubinaemia, hypoglycaemia and menigitis, in which more high pitched cries occurred. In asphyxia and menigitis, an increase in rising and falling/rising melody type and a more frequent occurrence of biphonation and gliding have been observed. No biphonation had occurred in the cries of infants with 13 and 18 trisomy. Gliding occurred in only one case. This was the only infant who had Apgar score at 5 minutes. The asphyxia might have affected the cry results in this case. The anatomical defects of physiological mechanism that change the cry pattern in chromosome anamolia are not known. (Michelson, Tuppurainen, Aula, 1980).

Fisichelli and Karelitz (1966) obtained samples of crying from four male mongloid infants, 6 months of age and four normal infants matched for age and sex and fed it into the panoramic sonic analyzer in order to survey the frequency content of the cries. Results showed that cries of normal infants were relatively homogeneous. The spectra of the mongloids showed greater variability within each spectrograms, more peaks and troughs were discremible indicating that the intensity variations were much greater for mongloids than they were for normal. The frequency content of the spectrograms of normal infants were much richer than that of spectrogram of monogloids. But the spectral range covered by the mongloids was same as that of the cry of normal infants.

Lind et al (1970) studied cry samples of 120 normal infants 0-8 month old and 30 infants with Down's syndrome (21-trisomy). The results have shown that when compared to the cries of 120 healthy infants of corresponding age, the cries in Down's syndrome had a long duration with a mean of 4.5 seconds. In addition they were lower pitched with a mean of maximum pitch being 510 Hz and a mean of minimum pitch being 210 Hz. The melody was flat in 63% of the samples, biphonation occurred in 23% and stuttering in 53%.

CRY IN INFANTS WITH MALNUTRITION

Malnutrition is a problem in most countries of the developing world. According to Stock and Smythe (1967), Marasmic malnutirition during the first year of life can cause irreversible intellectual impairment and orsanic brain dysfunction. Sound spectrographic investigation of the cries of 5 infants aged 7 months to 2 years, with severe malnutrition (One with Kevashiorkar and four with Marasmus) were compared with cries of 15 healthy children of corresponding age. The mean maximum pitch was 1340 Hz, the minimum pitch was 730 Hz; biphonation occurred in 6 and 6 of the 26 cries had flat melody type. In Kevashiorkar, the pitch was 290 - 460 Hz was like the normal control cases (Juntunam et al 1972). Easter (1976) analyzed the cries of 13 well nourished and 12 mal nourished infants using real time analyzer. He found that crying of malnourished children had a higher pitch, lower amplitude, longer duration and longer latency to the next signal, compared to the normal subjects. The cries of the 12 malnourished infants were 2.66 versus 1.52 secs, for the control. The pitch was 480 Hz as compared to 308 Hz. for the controls. Cries of children with severe malnutrition were studied by Juntunen, Sirvio, Michelsson (1976). In infants suffering from Kwashiorkar, cry characters did not differ from normal crying. The children often recover with out sequalae.

CRY IN INFANTS WITH CENTRAL NERVOUS SYSTEM DISEASES:

The cry of 14 infants with bacterial meningities was studied by Michelsson et al (1977). The cries of the 0-6 month old infants were high pitched, with a mean maximum pitch of 750 Hz. in the 110 cries studies. The mean minimum pitch was 560 Hz. Rising and falling/rising melody type were more common (24%) than in control babies. Biphonation (49%) and glide (11%) occurred more frequently. Infant who at later check up had neurological sequelae had more abnormal cry characteristics at time of the disease. The results indicated that cry analysis had not only the diagnostic but also progrostic value when cries of infants with meningitis were analysed.

In cries of infants with herpes simplex virus encephalitis (Pettag et al 1977), noise concentration occurred at the frequency region of 2000 - 3000 Hz. The cries were more high pitched. Both biphonation and glide were more common than in healthy controls. Study on crying in children with hydrocephalus was done by Michelsson, Kaskinen, Aulanko, Rinne (1984). The cry analysis of 248 cries - 4 cries from each of 62 infants were analyzed. The mean maximum pitch without shift was 750 Hz. When the infants with hydrocephalus was separted into group according to etiology, the only significant difference in the maximum pitch when compared to controls was noted in infants who had congenital hydrocephal present at birth. Flat types of melody were common regardless of the cause of hydrocephalus. Biphonation occurred in 14% and glide in 8% in the whole material.

The cry results show that the cry is different from normal crying in diseases of CNS. Biphonation was more common in menigitis than in encephalitis and hydrocephalus. Noise concentration occurred in herpes encephalities. All groups of children had more higher pitched cries than controls. In infants with congenital abnormalities such as

Down's syndrome (Wasz - Mockert et al 1971), Hypothyroidism (Michelsson and Sirrio 1976) and congenital syphilis (Kittel and Hecht 1979), the cry was low pitched, Thus it is obvious that the results of cry analysis are different in children with acquired and cogenital disorder of the CNS.

Lind et al (1965) reported a cry analysis of infant with brain damage from a birth injury. This found a fundamental frequencies of 450 - 2070 Hz as compared to 280 - 900 Hz of a group of 20 controls. Michelsson et al (1980) analyzed the cry in hydrocephalus. Cries with a mean of maximum pitch over 1000 Hz were noted in these infants who in addition to the hydrocephalus had cogenital malformation of the brain (Rosemcephalus/Hydranencephalus). The cry changed to a more normal one after the shunt operation for hydrocephalus with the increased intral cranial pressure was normalized.

CRY IN INFANTS WITH METABOLIC DISTURBANCES:

The cry of infants with neonatal hyper bilirubinenia was reported by Wasz - Hockert et al (1971). The most abnormal cry signals were selected from 45 infants with hyper bilirubinemia. Both the maximum and minimum pitch of the fundamental frequency were highly increased. The mean maximum pitch was 2120 Hz and the mean minimum pitch was 960 Hz. Biphonation was common in 49% of the samples as was furcation, in 42% of the samples. Furcation has been seen more commonly in pain cries of infants with hyperbilirubinemia than cries of infants with any other disease.

Wasz - Hockert et al (1971) noted also that the cries of some children with hyperbiliribinemia changed already 1 to 2 days prior to increases serum bilirubin values. The cry analysis method can thus enable early treatment with photo therapy or blood exchange. A cry score rating system that was developed by Vuovenkesti et al (1971) has been used in analyzing cries of 45 infants with hyperbilirubinaemia. Each of 13 cry feature were assigned a weightage of 0 to 4 and the cry score was the sum of these ratings. A score of 0-3 was defined as normal and a score of 4-5 was defined as abnormal. A mean score of 4.4 was found in the case of infants with hyperbilirubinaemia as compared to a score of 1.4 in the group of control infants. Only one of the 45 infants with jaundice had a normal score.

A preliminary report on the crying of newborn infants with low blood sugar hypoglycemia was reported by Koivisto etal (1974). Hypoglycemic infants with clinical symptoms are more likely to develop irreversible brain damage than those without symptoms (Koi-visto, Blanco, sequeivois & Krause, 1972). Cry analysis can be one criterion in deciding which treatment is needed. In cries of 15 full term infants with hypoglycemia and clinical symptoms, a mean maximum pitch of 1000 Hz was noted with highest part of the fundamental most often at the beginning of the cry signals. Vibrato and biphonation were seen in about two thirds of the cries. Glides occurred in 3 of the 17 cries studied.

In analyzing cries of new born infants of diabetic mothers, Troden and Michelsson (1979) found higher fundamental frequency with a mean maximum pitch of 1180 Hz. The maximum pitch was still higher when the child in the neonatal period additionally had hypoglycaemia (1520 Hz) or hyperbilirubinaemia (1790 Hz) or both simultaneously (1980 Hz). The minimum pitch in cries of infants of diabetic mothers was 510 Hz. When the babies additionally had both hypoglycaemia and hyperbilirubinaemia, the minimum pitch was 690 Hz. Thus the study clearly showed that the cry analysis was an indicator of the severity of the disease in the neomatal period.

The results of cry analysis of infant with hyperbilirubinemia were confirmed by Michelsson, Raes, Thoden and Wasz-Hockert (1982). These results showed that the cry characteristics changed whether child was born full term or premature.

CRY IN INFANTS WITH ENDOCRINE DISTURBANCES:

The cry in congential hypothyrodism studied in 40 cries of 4 infants by Michelsson & Sirvio (1976) was of lower pitch than usually seen in cries of healthy infants. The mean maximum pitch was 470 Hz. and mean minimum pitch was 270 Hz. A low number of shifts, 7% and a frequent occurence of glottal roll, 57% at the end of the phonation accentuated the audible impression of a hoarse low pitched cry. The hoarse cry seems to persist for several months. Cry characteristics which occur in brain damaged infants such as the change in the melody type and occurence of biphonation and gliding did not occur in hypothyrodism. Thus the change seen in brain damage and seem to be more of a peripheral nature.

Perkins & Barnett (1972) had stated that the hoarseness in hypothyroidism was due to odeme in larynx. Vuoren Koski, Anltholanen (1993) showed that even at the age of 8 months a child who suffered from congenital hypothyroidism did not had any cries with a pitch above 1000 Hz.

CRY IN TWIN PAIRS:

A study on cries in twins has been carried out by Michelsson and Rinne (1984). The results showed that cries in twin pairs who were both healthy were more equal than the cries in twin pairs in which one was healthy and other was diseased. The study also confirmed previous results that cries are more abnormal than the more premature the infant is.

Michelsson, Raes & Thoden 1982, analyzed 90 cries from two pairs of Siamese twins. The results showed that cries of conjoined twins fell well into normal limits for crying. Cry features of set of quadruplets was reported by Thoden, Raes, Michelsson (1979).

CRY IN INFANTS WITH OTHER DISORDERS:

Blinick et al (1971) have stated that 15% of 330 normal infants and 50% of 31 new born infants of narcotic addicted mothers showed abnormal birth cries with a higher fundamental frequency. Ostwald et al (1968) determined the relationship between clinical diagnostic ratings and 2 acoustical characteristics pitch and duration. The subjects were 5 normal infants, 5 questionable impaired and 5 abnormal. Duration measurements showed no difference between the groups. The infants rated as impaired or abnormal had cries with a high frequency of 300 - 2875 Hz. and the normal group had a frequency of 360-785 Hz. A study of the cry of a 4 day old full term normal baby who at 6 months died suddenly showed that the cry in sudden infant death syndrome (SIDS) had a higher frequency or more shifts and more extreme frequency (Stark and Mathanson 1975).

Anderson - Huntigton & Rosenblith (1976) also mentioned abnormal cries in their report of babies who died of SIDS. Tardy - Renucci and Appaix (1978) found a mean fundamental frequency of 512 Hz in a group of 68 infants with various neonatal disorders such as hyperbilirubinamea malformation syndrome, anoxia and respiratory disorders. They have defined the cry as a "reflex motor action under the dependence of the nervous centres", further have stated that cry" can be modified by diverse physiologic and pathologic processes". The highest mean fundamental frequency in infants with

Jaundice was 630 Hz 1 in 3 who had been resusciated after birth 613 hz. In 9 control infants it was 470 Hz.

Lester and Seskind (1978) found a mean pitch of 814 Hz in the cries of 24 healthy new born infants with maternal risk factors when compared to 468 Hz for 24 healthy newborn infants without pre or perinatal complication. In infants with risk factors, cry was elicited after repeated snaps. The latency of infants with risk factors was 21.1 secs, and for those without risk factors it wad 1.4 secs. In infants at risk cried less (13.7 secs.) than infants with no risk factors (21.3 secs.).

Thoden and Michelsson (1979) analyzed the cries of 3 infants with Krabbe's disease. They noted a mean of maximum pitch being 1120 Hz of a mean of minimum pitch being 590 Hz. in these infants. The control group had a mean maximum pitch of 520 Hz and a mean minimum pitch of 370 Hz. There was siginficantly less falling and rising-falling melody type in Krabbe group and these children also produced continous signals less often.

Michelsson et al (1982) collected during a two month period, the cries of all infants admitted to the ward for new born and small babies. The sound spectrographic cry analysis was performed blinding or without any knowledge of the infant with clinical diagnosis to confirm whether cry analysis is useful in neonatal diagostics and especially if it can be additional means of estimating the conditions of CNS. The infants were divided into 4 groups and the results of the cry analysis, for the full term and the premature babies was considered separately in each group. 4 groups were 1) observation group 2) Oardio pulmonary disorder group 3) Metabolic disturbances 4) Neurological symptom group. The control series consisted 110 pain cry signals from healthy, full term 0-3 month old infant. The results reported are as follows:

a) Fundamental frequency:

This study confirms the previous investigations as the pitch was higher in the cries of infant with metabolic and neurological disturbances. In other two groups, there was nonsignificant increase in fundamental frequency. In the observation group, the highest pitch was found in an infant, delivered with the help of vacuum extraction which might possible have affected CNS. In the cardio-pulmonary group, the highest fundamental frequency was noted in the infants with cyanotic congeital heart disease which can affect the brain structures through hypoxia. In the neurological symptom group, the highest maximum pitch was observed in a child with bacterial menigitis and lowest in those with microcephalus. This indicates that acute cerebral damage give rise to more changes in cry characteristics than prenatally developed anamolies.

b) Melody type:

There was an increase in the rising and falling/rising types of melody in full term infant with metabolic disturbances and neurological symptoms. This indicates that change in melody is determined by CNS.

c) Biphonation and glide:

They are rare in cries of healthy infants, occurred more often in all abnormal groups in the full term infants but the significant level was greater in the cardio pulmonary, metabolic and neurological groups than in the observation group.

d) Furcation:

This has previously been connected with hyperbilirubinaemia (Wasz - Hocket et al 1971). In this study 2 of 5 cries with furcation were from infants with hyperbilirubinaemia.

e) Noise concentration:

This was observed in 5 of cries. One of these infants had laryngo malaria and convulsions and one had virus infection of unknown etiology.

f) Durational feature:

The latency of the cries in all the disorder group was longer than the latency of the controls. No differences in latency could be seen between the disorder groups.

The authors imply that their data provides a firm foundation for critical objective evaluation of the cry in sick infants especially when the cry is involved.

Venugopal (1995) studied the developmental changes in infant cry. The study was carried out on normal infants 24 hrs from birth to 3 months. The acoustic parameters of infant cry was studied using multidimensional voice programme. The results indicated following:- In average fundamental frequency, Average pitch period, Highest Fo, Standard deviation of FO, Amplitude tremor frequency, Fundamental frequency variation, Shimmer percent, smoothed amplitude perturbation quotient, peak amplitude variation, Degree of voice break, Degree of sub harmonic segment, Numer of sub harmonics. Significant differences was observed but it was not consistent over period. Significant difference was not oserved for lowest Fo, Fo-Tremor frequency, Absolute Jitter, Jitter percent, Relative average perturbation, Shimmer in dB, Noise to harmonic ratio, Soft phonation index, Degree of voicelessness, Number of voice breaks, FO-Tremor intensity index, Amplitude tremor intensity index.

Indira Nandgal (1984) analyzed cries of 13 normal full term infants and 28 infants belonging to the high risk category. The age range of infants was 10 hours to 3 months.

Pain cries were elicited form these infants by flicking the sole of infant foot with index finger till they cried atleast for 30 seconds. The cries were recorded with cassette taperecorder. The recordings were made at a constant intensity level with a microphone held approximately 5 cms. from infants mouth to reduce back ground noise to a minimum. Cry samples were analyzed to obtain narrow band spectrogram. These spectrogram were analyzed.

Based on analysis and interpertation of spectrogram by the various cry characteristic, following conclusion have been drawn.

1) Significant difference exists between cries of normal and high risk infant in terms of some cry characteristics like fundamental frequency, duration of cry, double harmonic break, glottal plosive which are found more in cries of normal infants.

2) No significant differences were observed in both the normal and high risk infant in cry characteristic like shift, biphonation, glide and tonal pit.

3) 8 categories of high risk infant were studies and it was found that each group exhibited cry characteristic which were distinctive to infant with that particular history or problem.

CHAPTER - III

METHODOLOGY

The aim of the study was to find out the differences between the Normal and the abnormal infant cries by spectrographic analysis.

For this purpose the study was carried out in the following steps.

1) Administration of the questionnaire regarding the high risk factors to the parents of the infants.
2) Collection of data i.e., cry samples of normal and high risk infants.
3) Spectrographic analysis of infant cries.
4) Follow up of the infants for hearing screening and to collect information about developmental milestones.

a) Administration of Questionnaire:

Questionnaire which consisted of questions regarding high risk factors, along with other prenatal, perinatal, postnatal history like prematurity, asphyxia, Jaundice etc. which may lead to CNS abnormality were administered to the mothers of the infants. The case history was drawn up with all the factors taken into considerations (Appendix A and B).

b) Data Collection:

Infant cries of 28 normal full term infants and 34 infanta considered to be with high risk factors according to the case history were recorded. Infants were from neonatal and sick baby wards of Cheluvamba Hopital and J.S.S. Hospital, Mysore. The age range of infants were from 16 hours to 1 1/2 Months.

Group I:

In this group, pain cries of 28 normal infants from neonatal wards were recorded. The age range was from 16 hours to 1 1/2 Months. These infants had no peri, pre (or), post natal factors to place them in high risk category. They were born after 37 weeks of gestation and their birth cries and birth weights were considered normal. This was confirmed after enquiring the Mothers and from the information collected from hospital records.

The pain was elicited by flicking sole of infant's foot with index finger. When infant didnot cry immediately, it was stimulated again, till it cried for atleast more than 30 seconds. However if infant cried for longer period and if especially the infant had some serious high risk facotrs, recording was stopped even before infant stopped crying.

The cries were recorded using V-sensor (AIWA) cassette recorder and piezo dynamic microphone. The cassette was Meltrack DRC-90°C. Taperecorder was battery operated. Every day prior to recording voltage of batteries were checked. All recordings were made at constant intensity level. The microphone was held 5 Cms. from infants mouth to reduce background noise to minimum.

Group 2:

In this pain cries of 34 infants from sick ward who were considered to be with history of high risk factors were recorded. The procedure for eliciting pain cries and recordings were same as used in Group I. Information obtained from the mothers and hospital records revealed that these infants had one/more of high risk factors. Table (2.1.1) gives details of different high risk groups considered, Number of infants in each group, age range and sex.

Table 2.1.1

Problem	No.of Subject	Sex	Age Range
Preterm	8	6 Males 2 Females	2-6 days
Lowbirth weight	2	2 Males	2 - 11 days
Metabolic disorders	2	1 Male 1 Female	1 - 3 days
Jaundice	1	1 Female	3 days
Asphyxia	4	2 Males 2 Females	4 - 9 days
Hydrocephalus	2	1 Male 1 Female	5 - 7 days

PHOTOGRAPH SHOWING THE INSTRUMENTATION FOR THE ANALYSIS OF INFANT CRY type spectrograms or the decided parameters. The following 14 parameters was studied from spectrograms:

I. Durational features a) Total duration b) Second pause.

II. Fundamental Frequency Features a) Maximum Fo b) Maximum Fo c) shift d) Glide e) Noise concentration f) Biphonation g) Furcation h) Double harmonic break i) Glottal plosive j) Vibrato k) Tonal pit 1) Melody.

Follow Up:

Follow up was done with the purpose of collecting information regarding developmental milestones and hearing sensitivity of infants. The follow up was carried out for infants belonging to group 1 (normal infants) and Group 2 (high risk infants) 3 months after data collection, so that the infants were atleast 3 months of age by that time.

Follow up was done in 2 ways:

1) The local residence of Mysore were visited at their home. Auditory screening of it infants was carried out with toys emitting low frequency and high frequency sound. Information regarding developmental milestones like head held up and grasping etc were collected from the parents.
2) For non local residents of Mysore follow up was done through correspondence. A questionnaire including questions about developmental milestones and hearing ability of infants were sent to the parents. (Given in Appendix - C).

Criteria for Normacy:

Norms established for Indian population by Hegde (1971) were used to find out if milestones of infant were delayed or not: If infant responded well to screening, their hearing ability was considered normal. Those who didnot respond properly to screening were classified as abnormal and parents were advised to bring the child for a follow up at AIISH to confirm or rule out hearing loss. Similarly if infants had delayed developmental milestones they were referred to AIISH.

CHAPTER - IV

RESULTS AND DISCUSSION

The cries of 28 healthy infanta and 34 infants with various high risk factors like prematurity, asphyxia, jaundice, meningitis, convulsions, metabolic disorders, low birth weight, respiratory disorders, and hydrocephalus was studied.

The spectrograms were analyzed to note the following parameters:

1. Duration of cry, 2.Second pause, 3.Minimum frequency, 4. Maximum frequency, 5. Shift, 6.Glide, 7. Noi3e concentration, 8. Biphonation, 9. Furcation, 10.Double harmonic break, 11. Glottal plosive, 12. Vibrato, 13. Tonal pit, 14.Melody.

GROUP 1:-CRY IN HEALTHY INFANTS

28 infants -16 males and 12 females in the age range of 1 day - 45 days were considered under this group. The results of the cry analysis of healthy infants are given in the Table 4.1.1.

The results are presented considering the group as a whole, that is both males and females, since no differences between the cries of males and females are reported in the literature.

The means of minimum frequency and maximum frequency noticed were 317.86 and 630 hz.Range was 160 -460 hz respectively. Infant no. 12 had the highest range of fundamental frequency 380 - 1460 hz. The mean duration of the cry and second pause was 14.2857 and 0.401782 sec respectively. Most infants had a rising - falling melody pattern. Two infants had flat pattern while remaining one had rising pattern. Double harmonic break (mean = 3.39) and shift (mean = 4.54) occured in almost every cry. Glottal plosive (mean = 2.93) and vibrato (mean = 2.34) occured most often. Among all the characteristics, biphonation (mean = 1.79) and furcation (mean = 1.18) occured rarely. These results are given in the table 4.1.2.

GROUP 2:- CRY IN INFANTS WITH VARIOUS HIGH RISK FACTORS

34 infants -23 males and 11 females in the age range of 1 day - 45 days were studied under this group. All the high risk factor infants were considered as a group. The mean of minimum and maximum frequencies were 424.7059 Hz and 788.2353 hz. The ranges were 320 -1560 hz and 180 -2200 hz respectively. Infant no. 11 of this group had highest range of fundamental frequency i.e 420 -1360 hz.The mean duration and second pause of cry was observed 12.9853sec and .7296 sec respectively.

Noise concentration (mean = 11.8824) was the one which occured most commonly in infants of thi3 group. Biphonation (mean = 2.5882) and furcation (mean = 2.4706) occured most commonly in these infanta.Results are given in the table 4.2.1 and 4.2.2.

Table 4.3 shows the comparision of normal and high risk infants using Mann -Whitney 'U' test. Normal infants had mean shift, vibrato,tonal pit,glottal plosive, double harmonic break and duration of the cry to be greater than in the infants with high risk/ infant with the history of high risk factors, who had second pause,furcation, biphonation, noise concentration, glide, fundamental frequency both minimum frequency and maximum frequency to be greater than in normals. However statistically significant difference were observed only for the following parameters.1.Second pause 2.Maximum frequency 3. Shift 4.Noise concentration 5. Furcation 6. Double harmonic break 7.Vibrator.

Thus the null hypothesis stating that no significant difference will be observed between the cries of normal healthy infants when compared to infants with the following characterstices 1.Total Duration of the cry. 2.Second pause . 3.Minimum frequency 4.Maximum frequency. 5.Shift . 6. Glide. &.Noise concentration.8. Biphonation. 9.Furcation. 10.Double Harmonic Break.11. Glottal plosives. 12.Tonal pit.13.Vibrato. 14.Melody, as measured using spectrograms is partly rejected and partly accepted. It is partly accepted because no significant differences were observed in the cries of both the normal and high risk infants in cry characterstics like total duration, minimum fundamental frequency, glide, biphonation, glottal plosive and tonal pit. It is partly rejected as significant differences between the criess of normal and high risk infants were noticed in some cry characteristics like maximum fundamental frequency, second pause, shift, noise concentration, furcation, double harmonic break and vibrato.

Graph 4.1(a) and (b) shows the comparison of normal and high risk infants on the various selected parameters. A comparison of normal group (Groups 1) with a group of abnormal infants with various histories revealed that all the cry characteristics may occur in both the groups. However, similar to the reviewed literature some of these characteristics occur distinctively more number of times in infants with a particular history (or) problem. For example: It has been reported that double harmonic break occurs more in healthy babies than in abnormal infants. (Michelson, 1971; Michelson et al., 1975). Similarily in the present study, double harmonic break had occured more number of times in the cries of healthy infants. Biphonation, glide, furcation and noise concentration were less than number of occurrences in normal infant when compared to high risk infants (Michelson, 1971; Thoden & Koivisto, 1980; Wasz-Hockert et al., 1968). Similar results obtained in the present study.

The review of literature available to the present investigator had shown no studies comparing normal with abnormal infants (have different histories and problems like prematurity, asphyxia, menigitis and Jaundice etc) as a whole group, except for the study done by Indira Nandyal (1982). However several studies comparing group of abnormal infants having a particular history (or) problem with infants were found in the literature (Michelson, 1971; Michelson, et al., 1974, Michelson and Sirvio, 1976; Michelson, Tuppurainen and Aula, 1980; Michelson et al., 1982).

In the present study not much difference has been observed in few parameters. This may be because of the fact that some of the characteristics been presented, more number of times by some infants in the normal group. For example: Subject 13 and subject 28 has showed glide 11 and 12 times respectively while all other infants showed the same characteristics less than 7 times. Subject 7 had shown the biphonation 9 times, while all other infants showed the same characteristic less than 4 times subject 8, 9, 12 has shown the noise concentration 21, 22 and 14 times respectively while none of the rest infants showed the characteristic to occur beyond 8 times. While similar conditions have been noticed with high risk infants. Subject 2 and 26 had showed shift 9 times and 10 times respectively, while all other infants had showed the same characteristics less than 7 times. Subject 29 and 35 had showed double harmonic break 11 and 7 times respectively in its occurence while none of the othere infants showed the characteristic to occur beyond 4 times. Therefore when a comparison is made considering all the abnormal infants with various histories as a group, it may not be possible to find distinguishing characteristics of problem group with specific history/problem. Hence it was decided to compare each abnormal group with specific history/problem, considered as a separate group, with normals.

TABLE 4.1.1: NORMAL INFANTS - NO.28

Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total duration	12	31	15	12	23	17	16	33	39	9.5	10	14	20	14	14	7
Second pause	3438	45	631	3312	6937	4562	2312	3562	5	25	425	575	493	2250	6187	463
Minimum Fo	320	320	260	300	460	320	280	380	220	220	440	380	360	280	380	160
Maximum Fo	540	560	600	520	600	520	480	560	500	460	660	1460	620	580	640	500
Shift	3	6	3	2	4	5	-	2	-	4	2	6	3	4	12	2
Glide	2	1	1	-	1	2	1	5	-	3	4	6	11	6	5	3
Noise concentration	-	12	3	3	7	4	4	21	22	8	6	4	-	4	12	5
Biphonation	-	-	1	-	1	2	9	3	4	2	1	7	-	4	1	-
Furcation	-	1	-	2	5	4	2	1	2	1	2		-	-	1	-
Double Harmonic Break	3	13	1	3	3	4	5	1	4	3	4		6	3	-	1
Glottal Plosive	2	2	2	2	4	4	2	9	3	4	3		8	4	4	9
Tonal pit	2	-	. 3	-	2	2	1	-	2	3	1		-	2	4	3
Vibrato	3	3	-	4	3	4	3	9	13	3	2		2	9	3	2
Melody	RF	RF	RI	RF	RF	RF	RF	RF	RF	FI.AT	RF	RF	RF	RF	RF	RF

RF - Rising falling pattern

17	18	19	20	21	22	23	24	25	26	27	28
12	8.5	15	19	15	5	7	7	7.5	5	4.5	13
4125	1312	5313	3125	425	375	3187	.3756	.4	4062	.3187	.5562
240	360	200	260	340	360	280	460	340	280	280	420
500	540	620	520	560	640	600	640	840	740	640	940
6	6	1	12	6	8	4	2	5	3	4	12
4	4	7	2	2	3	5	1	2	3	2	13
5	6	4	4	8	4	5	6	6	3	1	5
3	1	1		1	-	2	1	2	2	1	1
-	-	1	1	1	-	-	1	3	-	1	4
4	4	2	2	7	1	5	2	3	2	2	-
-	1	3	2	8	1	1	2	3	-	-	1
3	3	4	7	3	1	1	4	2	2	1	1
6	2	-	3	2	2	1	2	2	4	-	1
RF	RF	RF	RF	RF	RF	RF	FLAT	RISING	RF	RF	RF

TABLE 4.1.2: NORMAL INFANTS - NUMBER - 28

Parameters	Range	Minimum	Maximum	Mean	Standard Deviation
Total duraiton	34.5	4.5	39	14.2857	8.5564
Second Pause	.5875	.1062	.6937	.401782	.143708
Minimu Fo	300	160	460	317.86	77.43
Maximum Fo	1000	460	1460	630	194.10
Shift	12	0	12	4.54	3.26
Slide	12	0	12	3.63	2.90
Noise concentration	22	0	22	6.46	5.36
Biphonation	9	0	9	1.79	2.11
Furcation	5	0	5	1.18	1.33
Double Harmonic Break	13	0	13	3.39	2.60
Glottal Plosive	9	0	9	2.93	2.29
Tonal pit	13	0	13	3.25	2.89
Vibrato	8	0	8	2.34	1.88

TABLE 4.2.1: HIGH RISK INFANTS No. 34

Parameters	1	2	3	4	5	6	7	8	9	10	11	12	13
Total duration	12	41	9	5	4.5	3	4.5	11.5	10	10	9.5	5.5	7
Second parts	3.631	0.3125	2.369	0.35	0.25	0.9062	0.2188	0.43	1.61	0.4250)	0.5181	0.1812	0.1875
Minimum Fo	340	280	260	360	400	220	320	680	320	300	840	440	680
Maximum Fo	860	560	600	700	720	620	540	920	660	660	1340	980	1400
Shift	2	9	-	1	2	2	1	2	2	2	-	-	1
Glide	-	2	1	2	2	2	1	5	-	8	9	2	2
Noise concentration	10	13	8	7	5	6	6	11	6	6	14	6	6
Biphonation	2	2	1	-	-	-	2	4	3	2	1	3	4
Furcation	1	2	0	2	1	-	3	3	-	5	-	2	2
Double Harmonic Break	3	3	0	1	1	2	4	1	1	4	7	-	4
Glottal Plosive	-	3	3	1	7	1	-	5	2	6	-	2	-
Tonal pit	-	4	-	1	1	1	1	1	3	5	1	3	1
Vibrato	1	2	1	1	2	3	-	3	1	1	1	-	2
Melody	Flat	Rising	Rising	Flat	Flat	RF	Flat/ RF	RF	RF	RF	RF/ Falling	—	Flat

RF - Rising following

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
37	8.5	11	9.5	15	12	12	13	10	15	16	13	21	29	11	10.5	14
0.3187	0.3250	0.850	0.5062	0.9	0.6062	0.7813	0.8125	0.8750	0.7931	0.3375	0.3	0.3602	0.512	1.40	0.3250	0.4125
340	380	460	480	220	360	180	260	220	380	1560	280	320	320	420	820	420
520	780	960	1000	720	680	320	400	380	580	2200	560	560	680	1360	1220	680
3	3	3	2	7	9	4	-	-	3	3	1	10	6	3	2	7
6	7	6	4	9	14	-	4	1	10	7	1	28	5	4	6	26
37	11	7	7	21	13	10	14	14	11	13	13	31	3	17	13	15
7	-	-	2	6	1	3	4	-	3	9	2	10	2	3	2	2
4	1	2	-	5	1	4	4	-	2	3	-	17	3	1	5	2
3	-	3	-	3	4	3	3	1	1	1	-	2	11	2	1	7
4	-	1	2	3	4	3	2	2	5	1	4	2	2	3	1	-
2	6	5	1	7	7	4	1	-	5	1	-	9	2	1	-	8
1	1	1	2	1	3	2	3	-	5	-	-	5	4	1	-	-
RF	Rising	R/F	Rising	RF	RF	RF	RF	RF	RF/ Falling	Flat	Fall	RF	RF	RF	RF	RF

31	32	33	34
10	18	12.5	11
0.3502	0.3875	0.600	0.7813
360	320	280	620
560	600	460	1000
2	7	4	3
10	17	8	9
16	11	16	7
3	1	3	1
2	2	4	1
2	2	3	-
2	-	3	2
3	4	3	1
2	-	-	2
R/F	R/F	R/F	R/F

TABLE 4.2.2: HIGH RISK INFANTS - NUMBER 34

Parameters	Range	Minimum	Maximum	Mean	Standard Deviation
Total duraiton	38	3	41	12.9853	8.2467
Second Pause	3.45	0.18	3.63	0.7296	0.6887
Minimu Fo	1380	180	1560	424.7059	257.9198
Maximum Fo	1880	0	2200	788.2353	372.2533
Shift	10	0	10	3.1176	2.7498
Glide	28	3	28	6.4118	6.7292
Noise concentration	34	0	37	11.8824	7.0141
Biphonation	10	0	10	2.5882	2.4010
Furcation	17	0	17	2.4706	3.0074
Double Harmonic Break	11	0	11	2.2647	2.2062
Glottal Plosive	7	0	7	2.2353	1.8101
Tonal pit	9	0	9	2.7353	2.5022
Vibrato	5	0	5	1.4706	1.3977

TABLE - 4.3: TEST STATISTICS BETWEEN NORMAL AND HIGH RISK INFANT

	TD	SP	MIN	MAX	S	G	NC	BP	F	DMB	GP	V	TP
Mann-Whitney 'U' test	422.5	335.5	357.5	317.5	332	354.00	195	351.5	310	322	395.00	254	447
Asympotic Significance (2 tailed)	0.449 (MS)	0.047 (S)	0.093 (NS)	0.025 (S)	0.039 (S)	0.125 (NS)	0.000 (S)	0.073 (NS)	0.016 (NS)	0.027 (S)	0.244 (NS)	0.001 (S)	0.676 (NS)

* S - Significant difference

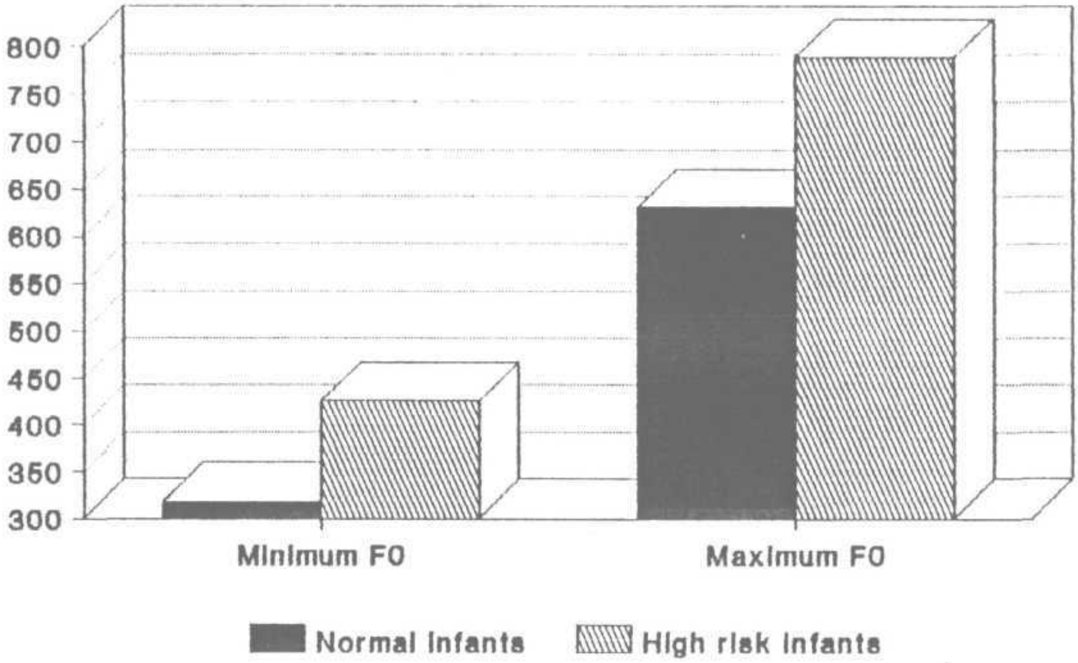
* NS - No Significant difference

Key Note:-

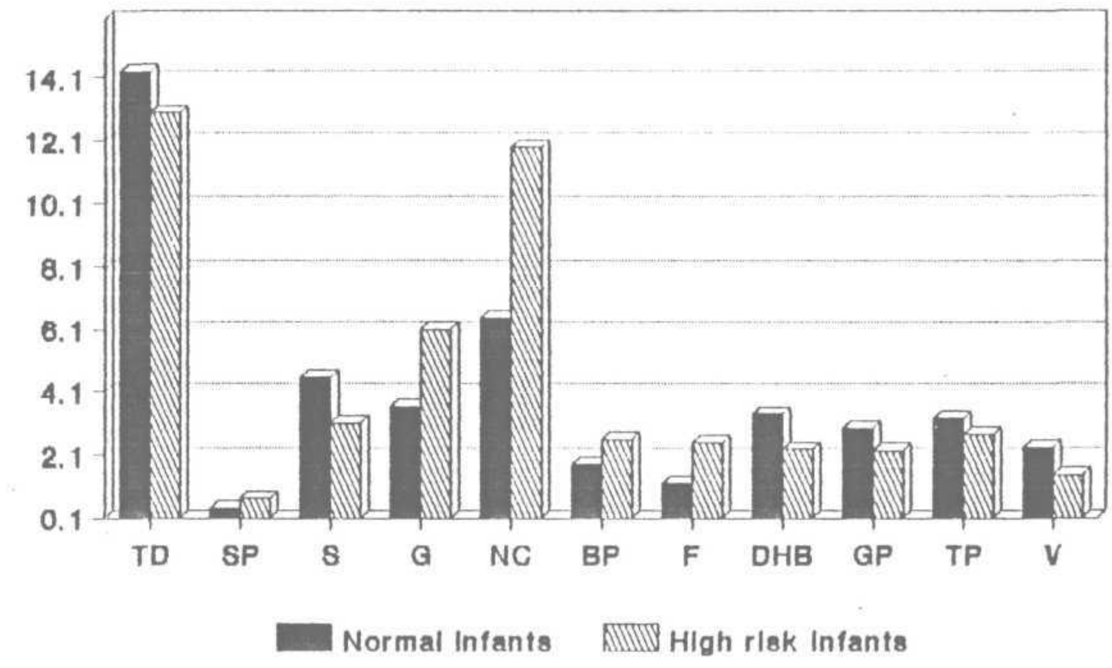
TD:- Total Duration
SP:- Second Pause
MIN:- Minimum Fo
MAX:- Maximum Fo
S:- Shift
G:- Glide
NC:- Noise concentration
BP:- Biphonation
F:- Furcation
DMB:- Double Harmonic Break
GP:- Glottal Plosive
TP:- Tonal Pit
V:- Vibrato

GRAPH 4·1A

Comparison of Normal and High risk infants



Comparison of Normal and High risk infants



CRY CHARACTERSTICS IN HIGH RISK INFANTS

CRY IN INFANTS WITH ASPHYXIA:

4 infants - 2 Males and 2 females in the age range of were found belonging to this group. The mean of Maximum frequency was 725Hz.

This was considerably higher than normals. The mean of minimum frequency was occursnce of mean. 350173. Second pause (0.646700 sec), Tonal Pit (4.25), Glide (Mean = 10), Biphonation (Mean = 3), Furcation (2.25), Noise concentration (Mean 12.5) was considerably higher than respective mean of normal infants. Vibrato (Mean - 2), and glottal polsive (Mean 2.5) were found to be little less than in normals, while double harmonic break (Mean 1.5), and shift (mean 4.75) were found to be almost equal to that occured in normal infants. 3 infants showed rising-falling patterns while one showed rising patterns while other showed falling pattern/ rising - falling pattern.

Michelsson (1971) in a study of 250 asphyxiated infants found that biphonation occured more than 20%, glide in more than 10% of sample with asphyxia. Rising and falling/rising types of melody occured in more than 30%. The findings of this study was some what similar to the present results study done by Indira Nandyal (1982) on 6 infants with asphyxia showed some findings which was similar to the present findings. According to her findings, melody was rising-falling in these infants. Noise concentration occurred more often in these infants than those in the normal category. Characteristics like vibrato, double harmonic break, shift, and glottal plosives found to be almost near (or) equal to the normal category. Refer to 4.4.1.

CRY IN INFANTS WITH LOW BIRTH WEIGHT:

2 infants (1 Male and 1 female) age ranged from constituted this group. Both mean of maximum and minimum frequencies were lower than in normals. The duration of cry was significantly high when compared to all other high risk babies and normals (Mean 23.5 sec). Biphonation (mean 3.50), Furcation (Mean 2.00), Noise concentration (Mean 25.30), and second pause (mean 0.596850 sec), were higher in their occurence when compared to normals. Occurrence of glides (mean 3.5 sec), glottal plosive (Mean 3.00), was equal to normals. However occurence of tonal pit, vibrato and double harmonic break was less than in normal infants. One infant had rising-falling pattern while for the remaining one a definite pattern could not be achieved. Refer to table 4.4.1.

Michelsson (1971) analyzed grils of 10 symptom less birth weight infants. The dominating melody type in all premature infant was falling (or) rising-falling, similar to the controls. Biphonation and gliding occurred in the cries of the prematured 5-14% of the time. No significant differences were seen in the occurence of double harmonic break (or) in the second pause. Laster and Zerkind (1978) found that underweight infants had higher, maximum fundamental frequency (740 hz) than babies with normal birth weight.

Cry in infant with convulsions:

The infant with history of convulsions had a minimum and maximum frequency of 340 and 860 hz. Cry duration was 12 secs. Second pause was 3.631 sec which was significantly higher than normals who had mean of 7296 sec. Melody was of flat pattern. Glottal plossive, tonal pit and glide did not occur at all. Biphonation, furcation, double harmonic and vibrato were rare. Table 4.4.2.

Sutdy done by Indira Nandyal (1982) on an infant with history of convulsions showed the following features-Maximum fundamental frequency of 1250Hz and a minimum fundamental frequency of 500hz. cry duration was 43 seconds. Glottal plosive did not occur at all. Tonal pit and biphonation were rare. This finding on glottal plosive, tonal pit, biphonation were similar to the present study.

Cry in infant with TEP fistula:

One infant, female aged 9 days with TEP fistula was studied. Cry duration was 14.257 seconds similar to normals. The minimum and maximum frequencies were around 260 and 400Hz. Shifts were absent, unlike normals. Melody was rising falling pattern. The occurrence of Biphonation, furcation, and glide were higher than normals. Occurrence of vibrato, tonal pit, and glottal plosives were similar to normals. Refer to table 4.4.2.

Review of literature available to the present investigator has shown no studies on infants with TEP fistula.

Cry in infant with neonatal jaundice:

In this group only one infant (female) was studied. The minimum and maximum fundamental frequencies were 180 and 320Hz which were comparatively lower than in normals. Second pause (.7813 sec) was significantly higher than in normals. Cry duration (12 secs), occurence of shift (4), tonal pit (2), vibrato (2), glottal plosive (3), double harmonic break (3) were similar to the findings of normal babies. Occurrence of noise concentration (14), biphonation (4), furcation (4) were higher when compared to the normal babies. Glide was absent and melody pattern was rising-tailing type. Table 4.4.2.

Study done by Indra Nandyal (1982) on 4 infants (3 Males and 1 female) in the age range of 2 days to 2 1/2 months revealed the following: the mean of maximum fundamental frequency was 2083.32 Hz, the mean cry duration was 37 seconds. Melody was rising-falling. Furcation (mean 5.6) and shift (Mean 7.6) occured more often in these infants than in normal category. There was no difference observed in the occurrence of double harmonic breaks between these groups and normal category. Noise conentrations occurred more often in this group when compared to healthy infants. Glide, tonal pit, biphonation, vibrato and glottal plosives were observed to be less in this group.

The cry of intants with neonatal jaundice has also been reported by Wasz - Hockert et al., (1971). Both maximum and minimum fundamental frequencies were high. Biphonation was common in 49% of the samples and furcation was, in 42% of the samples.

Cry in infant with hearing loss:

One Infant - aged 45 days, male with suspected hearing loss was studied. The baby did not respond to very loud sounds and needed excessive pain stimulation. Second pause (1.4 sec) and maximum fundamental frequency was significantly higher than in normals. Noise concentration was significanlty higher. Occurence of shift (3), glide (4), furcation (1), double harmonic break (2), tonal pit (1) and vibrato (1) were less than in normals. Siphonation was higher than in normals. Noise concentration was significantly greater when compared to normals.

Melody was rising-falling type. (table. 4.4.2.)

Cry in infants with hydrocephalus:

In this group, 2 infants- 1 male and 1 Female were available. The mean of maximum and minimum fundamental frequencies were 870hz and 420hz respectively which were higher than in normals. Occurrence of noise concentration (Mean=50), Tonal pit (Mean=5.5), glide (Mean= 0.50) were higher in this group than in normals. Biphonation was nil and occurrence of double harmonic break (Mean=1.50), furcation (Mean=1.50) was almost equal to normal infants, vibrato (Mean=l), total duration (Mean=9.75 seconds), shift (Mean=3), glottal plosive (Mean=l) were comparatively less than in normal infants. Melody was rising in one infant while other infant had rising-falling pattern (Table.4.4.3). Study done by Michelsson, Kashisen, Aulamko and Rinne (1984) on 284 cries of children with hydrocephalus found that maximum pitch was significantly higher when compared to controls. Similar results have been found in this study as reported by Michelsson et.al (1980).

Cry in infants with Respiratory distress:

In this group 2 male infants were studied. The Mean of Minimum and Maximum frequencies were was 5 20 and 810 hz which were comparatively higher than in normal infants. The occurrence of vibrato (Mean=2), tonal pit (Mean=1.0) and double harmonic break (Mean=l) were less than in normals. These infants had total duration (8.25 rec) and second pause (0.3900 rec) which was much less than in normal infants. Melody was flat type in one infant and rising-falling pattern in another one infant. The occurrence of biphonation

(Mean=2), furcation (Mean=2.5 rec), and noise concentration (Mean=9) were observed to be higher than in normals.

However, occurrence of glottal, plosives (Mean=2.13) shift (Mean=3.62) tonal pit (Mean=2.13) and vibrato (mean=1.50) were less than in the normal controls. The melody in general was rising-falling type, however 3 infants had flat pattern (Table. 4.4.3).

Cry in infants with Metabolic disorders:-

In this group, 2 infants - 1 male and 1 female were studied. Second pause (Mean = 0.41250 sec) and vibrato (Mean - 3 secs) were almost equal to normal infants. The mean of minimum and maximum frequencies was 580 Hz and 950 Hz which were significantly higher than in normal infants. The occurrence of furcation (Mean=8.5), biphonation (Mean = 5.5), glide (Mean = 18.5), Noise concentration (Mean = 22.5), shift (Mean = 5), and tonal pit (Mean = 3) were significantly higher than in normals, glottal plosive (Mean = 1.0), was less in, its occurrence when compared to normals. Total duration (Mean = 15.25 sec) was observed to be higher than in normals. Melody was rising-falling pattern (Table 4.4.3).

The cry of infants with hyperbilirubinemic has been reported by Wasz - Hockert et.al (1971). Both maximum and minimum fundamental frequencies were high. Biphontion was common in 49% of the samples, furcation in 42% of the samples. Investigators have reported that furcation had been seen more commonly in infants with hyper bilirubinemia than in cries with of infants with any other disorders. A preliminary report on the cry of infants with low blood sugar (hypoglycaemia) was reported by Koi vixto et.al (1974). In cries of 15 full term infants with hypoglycemia clinical symptoms, a mean maximum frequency of 1000hz was noticed with a highest part of fundamental most often at the beginning of the cry signals. Vibrato and biphonation were seen in about two thirds of the cries.

Cry in preterm babies:

8 infants - 6 males and 2 females age ranged were observed in this group. The mean of minimum and maximum of fundamental frequencies were 557.5hz and 977.5hz respectively which were considerably greater than in the normal controls.

The occurrence of biphonation (Mean=3.00), Furcation (Mean=3), glide (Mean=5), and noise concentration (Mean=9.5) were observed to be significantly higher than in normals. Also double harmonic break (Mean=3.62), second pause (Mean=450713) total duration of cry (Mean=16.125sec) were comparatively higher than in normals. However the occurence of glottel plosive (mean 2.13), shift (mean 3.62), tonal pit (mean 2.13) and vibrato (mean 1.50) were less than their normal controls.

The melody in general was rising-falling type, however three infants had flat pattern (Table 4.4.3).

Cry in other high-risk categories:

One infant with asphyxia and fits (No:34) and one infant with meconium aspiration with asphyxia (No:12) and one infant who had asphyxia with septicemia with menigitis (N.:25) were studied. Infant with asphyxia, and fits had both minimum and maximum frequencies greater than in normals (620 and 1000 Hz). Duration of cry (1120 cs), tonal pit (mean=l), vibrato (mean=2), glottal plosive (mean=2), were less than in normals. Double harmonic break was absent. Noise concentration (mean=l), glide (mean=7), second pause (.7813 sec), were higher than in normals and biphonation (mean=l), furcation were (mean=l), almost equal to normals. Melody was falling pattern. The infant, with meconium aspiration with asphyxia had total duration of cry of 5.5 secs. Shift, double harmonic break and vibrato were absent. A definate melody pattern was not observed (Table 4.4.4.). One infant with asphyxia with septicemia with meningitis had both minimum and maximum frequency less than normals (260 and 400 Hz) respectively. Shift was absent, noise concentration was very high (Table 4.4.4). Melody was of falling pattern.

5 more infants with combination of different high risk factors were also studied. Results are indicated in table 4.4.5.

TABLE - 4.4.1: Cry characteristics

HISTORY	SUBJECTS No	TD	SP	Cry characterstics Min	Max	S	G	NC	BP	F	DHB	GD	TP	V	M
	17	9.5	0.5602	480	1000	2	4	7	2	-	-	2	1	2	Rising
Asphyxia	18	13	0.9	220	720	7	9	21	6	5	3	3	7	1	Rising falling
	23	13	0.7931	380	580	3	10	11	3	2	1	5	5	5	Rising falling
	32	18	0.3875	320	600	7	17	11	1	2	2	-	4	-	Rising falling
Low Birth Weight	14	37	0.3187	340	520	3	6	37	7	4	3	4	2	1	Rising falling
	22	10	0.8750	220	380	—	1	14	—	—	1	2	—	—	Rising falling

TABLE - 4.4.2: Cry characteristics

HISTORY	SUBJECTS No	TD	SP	Cry characterstics Min	Max	S	G	NC	BP	F	DHB	GD	TP	V	M
Fits	1	12	3.631	34	860	2	-	10	2	1	3	-	-	1	Flat
TEP Fistula	21	13	0.8125	260	450	-	4	14	4	4	3	2	1	3	Rising falling
Jaundice	20	12	0.7813	180	320	4	-	10	3	4	3	3	4	2	Rising falling pattern
Hearing loss	28	11	1.4	420	1360	3	4	17	3	1	2	3	1	1	Rising falling pattern

Table 4.4.3: Cry characterstics

History	No	TD	SP	MIN	MAX	S	G	NC	BP	F	DHB	GP	TP	V	Melody
Hydrocephalus	15	8.5	325	380	460	3	7	11	0	1	0	0	6	1	Rising
	16	11.0	850	780	960	3	6	7	0	2	3	1	5	1	Rising Falling
Respiratory distress	5	4.5	.25	400	720	2	2	5	0	1	1	7	1	2	Flat
	8	11.5	-43	680	920	2	5	11	4	3	1	5	1	3	Rising falling
Metabolic disorders	11	9.5	5187	840	1340	0	9	14	1	0	1	0	1	1	Rising Palling
	26	21	3062	320	560	10	28	31	10	17	2	2	9	5	Rising Falling
Preterm	2	41	-3125	280	560	9	2	13	2	2	3	-	-	1	Rising falling
	6	3	9062	220	620	2	2	6	0	0	2	1	1	3	Rising Falling
	13	7	1875	680	1400	1	2	6	4	2	4	0	1	2	Flat
	24	16	3375	1560	2200	3	7	13	9	3	1	1	1	-	Flat
	27	29	512	320	680	6	5	3	2	3	11	2	2	4	Rising Falling
	29	0.5	3250	820	1220	2	6	13	2	5	1	1	-	-	
	33	12.5	6	280	460	4	8	16	3	4	3	3	3	—	Rising Faling

Table 4.4.4: Cry characteristics

History	No	TD	SP	MIN	MAX	S	G	NC	BP	F	DHB	GP	TP	V	Melody
Asphyxia with fits	34	11	7813	620	100	3	9	7	1	1		2	1	2	Rf
Meconium aspiration with asphyxia	12	55	4812	440	980		2	6	3	2		2	3		
Asphyxia with septicemia with menigilis	25	13	3	280	560	1	1	13	2			4			Rf

Table 4.4.5: Cry charateristics

History	No	TDi	SP	MIN	MAX	S	G	NC	BP	F	DHB	GP	TP	V	Melody
Septicemia with Jaundice with preterm	9	10	1.61	320	660	2		6	3		1	2	3	1	Rf
Acrocyanosis	30	14	4125	420	680	7	27	15	2	2	7	-	8	-	Rf
Respiratoty distress with septicemia	19	12	6062	360	680	9	14	13	1	1	4	4	7	3	Rf
Preterm with metobolic disorder	3	9	2.369	260	600		1	8	1	0	0	3	—	1	Rf
Preterm with respiratory distress	7	4.5	-2188	320	540	1	1	6	2	3	4	—	1	—	Flat

CRY CHARACTERISTICS OF THE GROUP WERE AS FOLLOWS:

Fundamental frequency:

The fundamental frequency was higher in high risk infants than infanta in the normal category in this study. Among the high risk category, premature infants had been found to have higher minimum fundamental frequency (infant no:24 -1560Hz, infant no:29 - 820 HE). Infant No:11 having metabolic disorder also had highest minimum frequency (840 Hz). The maximum fundamental frequency was highest in premature and asphyxiated infants. Premature infant No. 29, 24, 13 had maximum frequency of 1220 Hz, 2200 Hz and 1400 Hz respectively, asphyxiated infants No. 17, 34 had maximum frequency of 1000 Hz, and 1000 Hz respectively. Also infant No. 28 suspected to have hearing loss had maximum frequency of 1300 Hz and infant No.11 having metabolic disorder had maximum Fo of 1340 Hz. This infant also had high minimum Fo. Variability in minimum and maximum Fo had also been observed in the present study. Infant no.20 with neonatal jaundice had lowest minimum frequency (180 Hz) and infant 28 with history of low birth weight had lowest maximum frequency (380 Hz).

Study done by Indra Nandyal (1982) had reported findings similar to the present study. The fundamental frequency was higher in the high risk infants than in infants of the normal category. Among high risk categories, premature infants had been found to have highest maximum funamental frequency.

Greater variations were reported in the cries of high risk infants. Studies done by Michelson (1971) on 75 premature infant had revealed that fundamental frequency was highest in smallest prematures. Ternold et al., (1974) found that median fundamental frequency of first phonation in 5 premature was 752 Hz and 518 Hz for full term infants. The findings that premature had highest maximum fundamental frequency was found also in the present study.

Wasz Mockert et al., (1971) reported a mean of maximum fundamental of 2120 Hz in 45 infants with jaundice. Michelson (1997) compared cries of 205 infants with asphyxia with 50 healthy full term and 75 premature infants. The pitch of infants with asphyxia was reported to the higher than that of normal infants. The premature infants with cerebral asphyxia had highest maximum fundamental frequency. The results of the present study agree with these results. The infants with high risk factors of metabolic disordres prematurity and asphyxia had in general higher fundamental frequency.

Thus the present study, confirms the results of earlier investigations that the fundamental frequency is a good indicator of abnormality, especially in condition which could lead to CnS abnormality.

Duration of cry:

The total duration of cry was found to be high in high risk category infants than in normal infants. However the difference was not significant. Among all the high risk categories premature infants (No.2 - 41 secs; No.27-29 secs) and low birth weight infants (No.14-37 secs) had longest duration of cry. A lot of variability with regard to the duration of cry had also been noticed. Infant No.6 (preterm) had 3 secs; infant No.4 had 5 secs (metabolic disorders), infant No. showed 5.5 secs (respiratory distress); infant No.12 cried for 5.5 secs (asphyxia with meconimum aspiration) and infant No.7 cried for 4.5 secs (preterm with respiratory distress) and had lowest duration among all high risk infants.

The present study supports the findings of Indra Nandyal (1982). The study had revealed that cry duration in abnormal group was greater than in normal infants. The cry duration was longest in infants with asphyxia. These findings were not found in the present study. All the earlier studies in literature had considered the mean duration of first phonation, whereas in the present study the duration of whole cry has been considered. Duration, helps in differentiation of infants of different high risk groups.

Second pause:

The second pause was found to be higher in high risk infants than in normal infants. Mean of 0.7296 secs in normals and mean of 0.401782 sec in high risk infants had been found. Variability had also been noticed in high risk infants. 4 infants were found to have comparatively longer second pause than in normals and other high risk infants. (Refer to table 4.5.1). In general it was found that infant No. 1 who had history of fits had longest second pause (3.631 sec). Also infants with history of preterm with septicemia had longest second pause (infant 3 & 9).

Infant no.12 (asphyxia with meconium aspiration) and infant no.13 (pretrem) had shortest second pause among all high risk infants (0.1812 and 0.1875 sec respectively), followed by infant no.7 (preterm with respiratory distress) and infant no.5 (respiratory distress)who had second pause of 0.2188 and 0.25 secs respectively. No literature was available to present investigators regarding the second pause in normals and high risk infants. Refer to table 4.5.1.

Table - 4.5.1

Second Pause

No.	History	Second Pause in sec.
1	Fits	3.631 sec
3	Preterm with septicemia	2.369 sec
9	Septicemia with preterm with Jaundice	1.61 sec
28	(?) hearing loss	1.40 sec
12	Asphyxia with meconium aspiration	0.1812 sec
13	Preterm	0.1875 sec
7	Preterm with respiratory distress	0.2188 sec
5	Respiratory distress	0.25 sec

Shift:

Shift was found to occur more frequently in normals (mean 4.54 SD 3.26) than in high risk infants (mean 3.11764, SD=2.7498). Shift was absent in 5 infants. (Refer to table 4.5.2). It was found that metabolic disorders and preterm infants had highest occurence of shifts in high risk infafnts. However high variability had been observed.

The result support the findings of Michelson (1971) who reported more number of shifts in premature infants than in normal infants.

Table - 4.5.2

Occurrence of shift

No.	History	Occurrence of shift
3	Preterm with septicemia	-
11	Septicemia with Hypoglycemia	-
12	Asphyxia with meconium aspiration	-
21	TEP fistula	-
22	Low Birth Weight	-
2	Preterm	9
19	Bronchopneumonia, septicemia with preterm	9
26	Septicemia	10
30	Acrocyanosis	7
32	Asphyxia	7

4) Glide:

Glide occured more often in preterm, asphyxiated and infants with metabolic disorders, (refer to table 4.5.3). Glide was an abnormal characteristic and had been found to occur more often in all high risk categories. It was reported rarely in cry of healthy infants. Glide was absent in infant no.1 (fits), no.9 (septicemia, jaundice, preterm), no.20 (neonatal jaundice). This finding supports the findings of Indra Nandyal (1982) on glide occuring less in infants with jaundice than in normal groups. It also supports the findings of Michelson (1971). Michelson (1971) found that glide occured in 14% of cries of 205 infants with asphyxia. Gliding in 11% of cries of 14 infants with meningitis as reported by Michelson et al., (1977).

Table NO. 4.5.3. GLIDE

No.	History	Occurence of glide
19	Metabolic disorders	14
23	Asphyxia	10
26	Asphyxia with septemia with menigitis	28
30	Acrocynosis	26
31	Meconium aspiration	10
32	Asphyxia	17
34	asphyxia with convulsions	9
33	Preterm	8
10	Preterm	8
18	Asphyxia	9
15	Hydrocephalus	7
24	Preterm	7
11	Metabolic disorder	9

Noise concentration:

Noise concentration occurred more often in infants belonging to the high risk category (mean 11.8) than in normal infants (mean 6.46). High risk category like premature, metabolic disorders and asphyxia had maximum occurrence of noise concentration. (Refer to table 4.5.4). This finding were similar to report made by Indra Nandyal (1982). There were other reports available on the frequency of occurence of noise concentration in normals and infants with prematurity, asphyxia, jaundice and meningitis, to the present investigator.

Table No. 4.5.4. NOISE CONCENTRATION

No.	History	Occurence of Noise concentration
2	Preterm	13
1	Metobolism	14
3	Preterm with septicemia	8
8	Respiratory disorder	11
14	low birth weight	37
15	Hydroxia	11
18	asphyxia	21
19	Bronchopneumonia septecemia, preterm	13
20	Neonatal jaundice	10
21	TEP Fistula	14
22	Low birth weight	14
23	Asphyxia	11
24	Preterm	13
25	Asphyxia with covulsions	13
26	Metabolic disorder	13
28	Hearing loss	13
29	Preterm	17
30	Acrocynosis	15
31	Meconium aspiration	16
32	Asphyxia	11
33	Preterm	16

Biphonation:

In this study biphonation rarely when compared to infants of other high risk factors in both normal and high risk infants. Mean of normals was 1.79 and mean of high risk infants was 2.5882 Table 4.5.5. shows the occurrence of Biphonation in different high risk infants.

Table No. 4.5.5. BIPHONATION

History	No.	Occurrence
Respiratory distress	8	4
Preterm	13	4
Low birth weight	14	7
Asphyxia	18	6
TEP fistula	21	4
Preterm	24	9
Septicemia	26	10

Biphonation was found to occur in infants with preterm and did not occur at all in infants with hydrocephalus. These findings support the findings of Indra Nandyal (1982), Michelson et al., (1982) had found biphonation to be very sensitive in differentiating between normal and the disordered group. In the present study, biphonation was not found to be very helpful in differentiating between normal and the high risk categories.

Double Harmonic Break:

This was found to occur more frequently in normals (Mean 3.39) than in high risk infant group (Mean 2.2647) and difference was found to be significant. The frequency of occurrence of double harmonic break in the decreasing order as found in this study are -normal, preterm, convulsions and asphyxia. Double harmonic break was absent nearly in all infants with asphyxia. In preterm infants it occurred lesser than in normals but more than in any of other high risk categories. These results support the findings of the earlier investigations (Michelson et al., 1971). Michelson et al., 1977, Indra Nandyal (1982). Table 4.5.6. shows occurrence of double harmonic break in different high risk infants.

Table No. 4.5.6. DOUBLE HARMONIC BREAK

No.	History	Occurrence
7	Preterm with respiratory distress	4
10	Preterm	4
13	Preterm	4
19	Brochopnuenomia, septicemia & Preterm	4
27	Preterm	11
30	Acrocyanosis	7
3	Preterm with septicemia	-
12	Asphyxia with mecoicem aspiration	-
15	Hydrocephalus	-
17	Asphyxia	-
25	Asphyxia with convulsion	-
34	Asphyxia with convulsion	-

Furcation:

This characteristic occurred more often in high risk infants (Mean 2.4706) than in normals (Mean 1.18). This factor was maximum with infants having history of asphyxia with septicemia and meningitis, followed by infants with preterm. Variability of its occurrence with individuals with preterm was noticed in metabolic disorders. It also occurred frequently in infants with neonatal jaundice. This finding supports the reports made by Indra Nandyal (1982), Michelson et al., 1982 and Wasz Mockert (1971). Table 4.5.7. shows maximum occurrence and absence of furcation in different high risk infants.

Table No. 4.5.7. FURCATION

No.	History	Occurrence
7	Preterm with respiratory distress	3
8	Respiratory distress	3
10	Preterm	5
14	Low birth weight	4
18	Asphyxia	15
20	Neonatal jaundice	4
21	TEP fistula	4
26	Asphyxia with septicemia with meningitis	17
29	Preterm	5
33	Preterm	4
3	Preterm with septicemia	-
6	Preterm	-
9	Septicemia, with jaundice with preterm	-
11	Septicemia, with hypoglycemia	-
7	Asphyxia	-
22	Low birth weight	-
25	Asphyxia, with septicemia, with meningitis	-

Tonal pit:

Tonal pit occurred rarely in both normals and high risk infants. Findings supports results of studies by Indra Nandyal (1982). Tonal pit occurred more frequently in infants with history of preterm, asphyxia, septicemia, but also occurred in other high risk infant groups. However as a whole occurrence of tonal pit was less when compared to other parameters in both normals and high risk infants. High risk infants tended to show more occurrence of tonal pit than normals. Tonal pit was found to be absent in infants with history of fits. Based on his studies, Michelson et al., (1975) reported that this characteristic occurred more often in infants with anatomical defects of oral cavity like cleft palate. Infants with cleft palate were not available for the presence study.

Glottal plosive:

Glottal plosives occurred more in infant with history of preterm and respiratory distress. Apart from these it also occurred more often in normal infants (Mean 2.93) than in high risk infants. These findings were supported by study by Indra Nandyal (1982) and Michelson et al., (1971).

Vibrato:

Vibrato occurred more in normals (Mean 3.25) than in high risk infants (Mean 1.4706). The difference between them was significant. Vibrato occurred most often in premature infants, respiratory distress and asphyxia. High variability in its occurrence in preterm infants was noticed. Study by Indra Nandyal (1982) showed that vibrato occurred less in high risk infants except in premature infants than in the normal infants. These findings were supported by the present study. Michelson et al., (1982) had reported the occurrence of vibrato to the highest in infants with asphyxia. This finding was similar in the present study. Michelson (1971) did not find its occurrence in the cries of 205 premature infants. The present study also reported a high variability of occurrence of vibrato in preterm infants.

Melody:

Most of the infants in the present study, both normal and high risk category had a rising - falling Melody type (775%). The other melody patterns were flat (6 infants), no pattern (2 infants), rising (2 infants) and falling (3 infants). Refer to table 4.5.8.

Table No. 4.5.8. MELODY

No.	History	Melody
1	Fits	Flat
4	Preterm	''
5	Respiratory distress	''
7	Preterm with respiratory distress	''
13	Preterm	Falling pattern
24	Preterm	''
23	Asphyxia	''
25	Asphyxia with convulsion,	''
11	septicemia, hypoglycemia	''
12	Asphyxia with meconium aspiration	No pattern
22	Low birth weight	No pattern
15	Hydrocephalus	Rising pattern
17	Asphyxia	

All other infants had rising-falling pattern. Michelson (1971) reported an increase in rising - falling, rising types of melody in infants with asphyxia. In the present study infants with asphyxia had either falling, rising (or) no pattern. However the finding that most of the infants had rising falling pattern was supported by Indra Nandyal (1982). The present study did not find melody type to be distinctive to any group.

Thus the null hypothesis that no significant difference can be observed on various parameters measured using spectrogram between cries of normal infants and high risk infants is partly accepted and partly rejected i.e., accepted regarding because no significant differences were obtained on parameters like minimum fundamental frequency, total duration of the cry, glottal plosive and melody and hypothesis is rejected because significant difference were obtained on parameters like maximum fundamental frequency, second pause, double harmonic break vibrato, furcation, noise concentration and shift. Table 4.6 shows the occurence of cry characteristics in each high risk group infants in comparision to normal infants.

TABLE 4.6. SHOWING OCCURENCE OF CRY CHARACTERISTICS IN EACH HIGH RISK GROUP IN COMPARISON WITH NORMALS

SL. NO.	HISTORY	TP	SP	MINFO	MAXFO	S	G	NC	BP	F	DHB	GP	TF	V
	NORMAL	14.2857	0.40178	317.86	630	4.54	3.63	6.46	1.79	1.8	3.39	2.93	2.33	3.25
1.	Praterm	More	Equal	More	More	Less	More	More	Mora	More	Equal	Less	Less	Less
2.	Fits	Less	More	More	More	Less	Mil	More	Equal	Equal	Equal	Nil	Nil	Less
3.	TEP Fistula	Less	More	Less	Less	Nil	Equal	More	More	More	Equal	Equal	Less	Equal
4.	Hearing Loss	Less	More	More	Highest Occurence	Less	Equal	Highest Occurence	More	Equal	Less	Equal	Less	Learn
5.	Jaundice	Less	More	Less	Less	Equal	Nil	More	More	More	Equal	Equal	More	Less
6.	Asphyxia	Equal	More	More	More	Equal	More	Highest Occurence	More	Equal	Less	Equal	More	Less
7.	Low birth weight	More	More	Less	Less	Less	Equal	Highest Occurance	More	Equal	Less	Equal	Less	Less
8.	Septlcemia with jaundice with Preterm	Less	More	More	More	Less	Nil	Equal	More	Nil	More	Equal	Equal	Less
9.	Acrocynosis	Eqaul	Equal	More	More	More	More	More	Equal	Equal	More	Nil	More	Nil
10.	Respiratory distress with Speticemia with	Less	More	More	More	More	More	More	Equal	Equal	More	More	More	Equal
11.	Preterm with Metobolic disorders	Less	More	Less	Less	Nil	Less	More	Equal	Nil	Nil	Equal	Nil	Less

12. Preterm with Respitory distress.	Less	Less	Equal	Less	Less	Less	Equal	Equal	More	Equal	Nil	Less	Nil
13. Hydrocephalus	Less	More	More	More	Less	More	More	Nil	Equal	Less	Less	More	Less
14. Respiratory distress	Less	Less	More	More	Less	Equal	More	Equal	Equal	Less	Higest Occurence	Less	Less
15. Metobolic disorders	More	Equal	More	Highst Occurence	Equal	Highest Occurence	Highest Occurence	More	More	Less	Less	More	Equal
16. Asphyxia with Mecanium aspiration	Less	Less	More	More	Nil	Nil	Equal	More	Equal	Nil	Less	Less	Nil
17. Mecanium aspiration	Less	Less	More	Less	Less	Less	More	More	Equal	Less	Less	More	Lesss
18. Asphyxia with septicemia with Menigitcs	Less	Less	Less	Less	Less	Less	More	Equal	Nil	Mil	More	Nil	Nil
19. Asphyxia with convulsion	Less	More	More	More	Less	Less	Equal	Less	Less	Nil	Less	Less	Less

Results of follow up examination after 3-5 months:

Information was collected regarding the developmental milestones and hearing ability of infants 3-5 months after recording the cries. It was possible only to collect information from 14 infants (8 in normal category and 6 infants in high risk category). The inability to collect information regarding all the infants was due to following reasons:-

1) The cries were recorded when the infant was in the hospital and the information collected later from their homes. Some of the subjects were no longer available at the address given and in some ears were could not be located.

2) Of the subjects for whom follow up was done through correspondence, only few replied back to the questionnaire Few of questionnaires were sent back with no information.

All the 8 infants in the normal category were found to be normal on follow up examination. 2 of the infants in the high risk category were found to be 'normal' on the follow up. The infants considered to be normal had (1) Normal hearing ability as reported by parents and (2) milestones reported to be normal. 4 infants in the high risk category were confirmed to be 'abnormal' as two of them expired after few days, while remaining two had delay developmental milestones. These two infants were asked to come to All

India Institute of Speech and Hearing, Mysore. for detailed evaluation.

Thus the results of the present study indicated that the cry characteristics which were found by spectrographic analysis may occur both in the cases of normal and abnormals. Some of the characteristics were predominant in the normal group and some are predominant in the abnormal group. Some of them may occur in equal number in both the group. However based on further analysis, it has been found that each category of infants with specific high risk factor showed the occurrence of certain characteristics more frequently than in other groups. Therefore the analysis of cries would be very useful in early identification of abnormalities. Further it would also help in confirmation of diagnosis when abnormalities were suspected.

CHAPTER - V

SUMMARY AND CONCLUSION

The study of infant cry has provoked researchers for many years. In the beginning, cry studies were done based only on auditory analysis. Auditory differences between the cries of high risk infant compared to healthy infants have been recognised by paediatrician. The auditory investigation of infant vocalization have been mainly observation of when, why and how long babies cry (Michelson, 1981).

The objective analysis of the infant cries became possible when Potter et al., (1947) introduced the sound spectrograph. Vast body of research has provided much of justification and inspiration for using acoustic analysis of cries of an additional diagnostic tool in clinical paediatrics.

Using spectrograph, cries of normal infants and those infants with "various abnormalities have been differentiated based on various parameters of cry. (Wasz-Hockert et al 1971; Michelsson 1971; Michelsson et al 1975; Sivisio - Michelsson 1976). Based on previous literature and a need to differentiate between normal and abnormal infants, the purpose of present study was to analyze cries of normal and abnormal infants by spectrographic analysis and to note specific characters which will be distinctive to each abnormality.

The aim was to test the following hypothesis, "No significant difference exists between cries of normal healthy infants and infants with history of high risk factors (or) other problem on the following cry characteristics - Pitch (minimum and Maximum), shift, glide, melody type, glottal plosive, vibrato, tonalpit, Double harmonic break, biphonation, furcation, noise concentration. Total duration and second pause of cry signal.

The study was carried out in the following steps:

1) Construction of a list of high-risk factors for hearing loss and mental retardation.
2) Collection of data from normal and high-risk infants.
3) Spectrographic analysis.
4) Follow-up of the infants for hearing screening and to collect information about developmental milestones.

The list of high-risk factors was constructed from the high-risk register developed by Ashok (1981) and other pre-natal, peri-natal and post-natal factors like pre-maturity, asphyxia, etc., which may lead to abnormalities were added. The proforma for infant cry analysis developed in All India Institute of Speech and Hearing, Mysore was also used.

Cries of 28 normal full-term infants and 34 infants belonging to the high-risk category according to the case history were recorded. The infants were from the age range of 16 hours to 1 1/2 months. Pain cries were elicited from these infants by flicking the sole of the infant's foot with the index finger, till they cried for atleast for 30 seconds. The cries were recorded using a cassette tape recorder. The recordings were made at a constant intensity level with the microphone held approximately 5cms from the infant's mouth to reduce background noise to a minimum.

The cry samples were analysed to obtain narrow-band, bar-type spectrograms. These spectrograms were analyzed to note the occurrence of the following cry characteristics-

1) Duration of the whole cry,
2) Maximum fundamental frequency,
3) Minimum fundamental frequency,
4) Shift,
5) Double harmonic break,
6) Glide,
7) Biphonation,
8) Furcation,
9) Noise concentration,
10) Vibrato,
11) Glottal plosives,
12) Tonal pit and
13) Melody type.

A follow-up examination of the infants were carried out, 3-5 months after the recording, for the purpose of collecting information regarding developmental milestones and hearing ability of the infants.

Based on the analysis and interpretation of the spectrograms for the various cry characteristics, the following conclusions have been drawn:

1) Significant difference existed between the cries of normal and high-risk infanta in some cry characteristics like maximum fundamental frequency; second pause of cry, double harmonic break, vibrato, furcation, noise concentration, and shift.

2) No significant differences were observed in both the normal and high-risk infants in cry characteristics like minimum fundamental frequency, biphonation, glide, tonal pit, total duration of cry, glottal plosive and melody.

3) 12 categories of high-risk infants were studied. It was found that each group exhibited cry characteristics which were distinctive to infants with that particular problem or history.

Implications of the study:

1) Cry analysis is helpful in differentiating between normal and abnormal infant,
2) Infant cry analysis is a valuable tool in differential diagnosis of different abnormalities of infant,
3) It is useful for early identification of abnormal infants and thus in early rehabilitation (or) treatment.

Recommendations and direction for future research in infant cry are as follows:

1) A large number of infanta belonging to different high risk categories may be studied.
2) A follow up of infants in high-risk category upto one or two years to confirm or to rule out the abnormality would be useful.
3) Recording of the infant cries at the follow up examination would be useful.

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APPENDIX - A

List of High-Risk Factors

Father's Name: Age:

Mother's Name: Age:

Address:

Age of Child: Sex:

Questionnaire:

1) Has any of your close relative had a hearing loss since birth ? Yes/No
2) How is he or she related to this child ?
3) Do you know when and how he/she became deaf ?
4) Have you married your maternal uncle ? Yes/No
5) During your pregnancy did you have a rash with fever ? Yes/No
6) Did anybody tell you that you and your husband's Rh or blood groups do not match ? Yes/No
7) Prenatal during the 1st trimester of pregnancy, was the mother's health seriously affected as the result of injury or emotional trauma ?

- Nausia - Anemia - Accidents
- Vomiting - Bleeding - Nutritional difficiency
- Toxemia - X-ray - Virus infection
- Drugs

APPENDIX - B

DEPARTMENT OF SPEECH SCIENCES

ALL INDIA INSTITUTE OF SPEECH AND HEARING; MYSORE -570006.

PROFORMA FOR INFANT CRY ANALYSIS

Reg. No: Date:

Father's Name: Age: Education:

Address:

Permanent: Occupation:

Local: Telephone:

Mother's Name: Age: Education:

Habits: Tobacco/Pan Occupation:

Birth at:

Hospital / Nursing Home / Home Reg. No:

Sex of child: Male / Female Age. . . . . .days

Siblings:

Consanguinity: Yes / No Relationship:

Family background:

History of

1. Speech problems 2. Hearing impairment 3. Mental Retardation 4. Neurological Disorders: (a) Epilepsy (b) Cerebral Palsy (c) (d) 5. Other Congenital defects 6. Physical defects (specify) 7. Others	

8) Was there any history of miscarriages or still birth ?

Yes/No

9) Perinatal:

a) Duration of labour

b) Labour induced Yes/No

c) Delivery - Normal/caesarian/Forceps/Breech

d) Barbituates given to mother Yes/No

10) Condition of body

a) Birth cut. -

b) Jaundice -

c) Blueness - Asphyxiated

d) Full-term/Premature/Postmature

e) Birth cry - Present/absent/delayed

f) Convulsions/twitching/drowsiness/listlessness

g) Administration of oxygen

h) Incubator care - Yes/No

APPENDIX - B

DEPARTMENT OF SPEECH SCIENCES

ALL INDIA INSTITUTE OF SPEECH AND HEARING; MYSORE -570006.

PROFORMA FOR INFANT CRY ANALYSIS

Reg. No: Date:

Father's Name: Age: Education:

Address:

Permanent: Occupation:

Local: . Telephone:

Mother's Name: Age: Education:

Habits: Tobacco/Pan Occupation:

Birth at:

Hospital / Nursing Home / Home Reg. No:

Sex of child: Male / Female Age. . . . . .days

Siblings:

Consanguinity: Yes / No Relationship:

Family background:

History of	
1. Speech problems 2. Hearing impairment 3. Mental Retardation 4. Neurological Disorders: (a) Epilepsy (b) Cerebral Palsy (e) (d) 5. Other Congenital defects 6. Physical defects (specify) 7. Others	

Prenatal History:

1) History of Diabetes 2) History of Blood pressure
Yes / No Yes / No

3) Any illness of complication and treatment, describe

[Viral .... Infectious disease ....

Deficiency .... Tropical disease ....

Malnutrition ....]

4) Threatened Abortion:
(Bleeding in 1st trimester)

5) Abortions if any:
When:

6) History of Toxaemia of Pregnancy

7) Medication given:

a) Aminoglycocites

b) Quinine

c) Chloroquine

d) Others

8) Exposure to Radiation:

When:

9) Blood Group:

i) A B 0

ii) Rh (+) (-)

iii) Rh incompatibility Yes / No

iv) VDRL (+) (-)

10) Other relevant findings:

Natal History:

From Parents and Medical Records:

1. Full term:

2. Premature: (a) months. . . . . .days....

3. Post term: (b) months. . . . . .days....

4. Normal Labour Pain / Induced Labour Pain

5. Normal Delivery:

6. Breach Delivery:

7. Instrumental Delivery:

8. Prolonged labour:

9. Caesarian Section: (a) Elective

(b) Emergency

10. General Anaesthesia

11. Meconium stained amneotic fluid:

12. Birth cry: Normal / Delayed

i) How long
ii) Procedure to elicit cry:
iii)

13. Birth Weight. . . . .

14. as the child kept in the Incubator

15. Hypoxia:

16. APGAR Score: (a) Immediate

(b) After 5 mts.

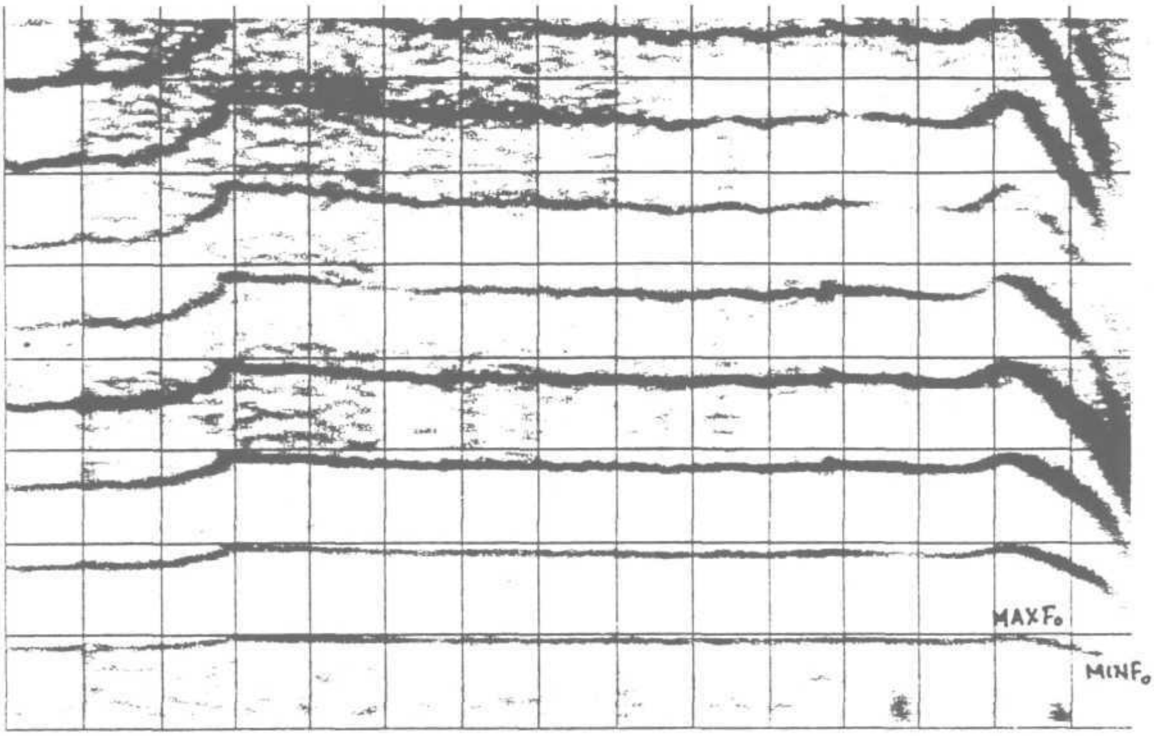
17. Any congenital abnormality:

18. Any other findings:

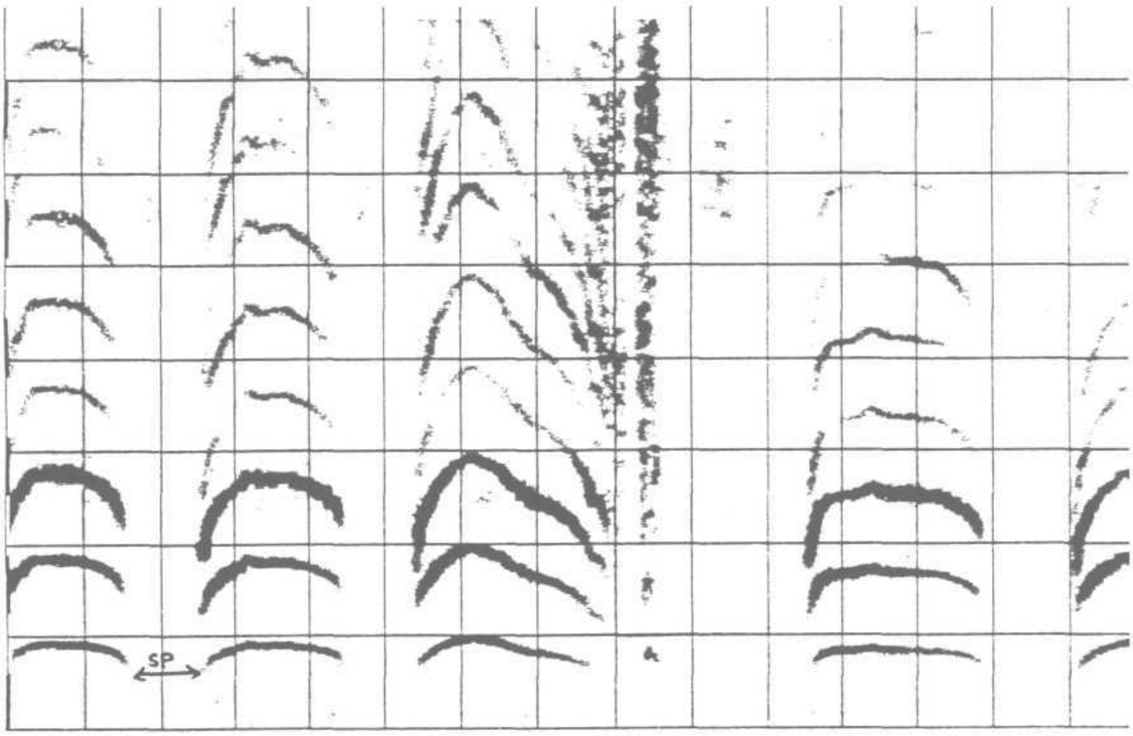
Obstetrician's opinion:

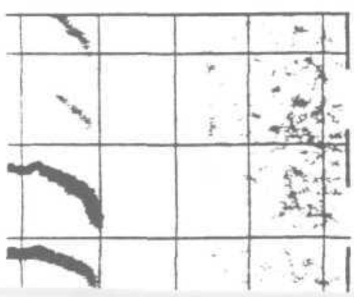
SPECTROGRAPHS SHOWING DIFFERENT CRY CHARACTERSTICS

APPENDIX D



MINIMUM AND MAXIMUM F_0





SECOND PAUSE

APPENDIX C

ಅಖಿಲ ಭಾರತ ವಾಕ್ ಶ್ರವಣ ಸಂಸ್ಥೆ, ಮೈಸೂರು ೫೭೦ ೦೦೬

Postnatal care:

1. Was the child given any medication:

   (i) How: IM / IV
   (ii) Why ?
   (iii) What drug ?
   Dosage:

2. Did the child have Jaundice on

   (i) First day
   (ii) Later
   (iii) is progressives

   Treatment given: (a) Phototherapy
   (b) Exchange transfusion
   (c) Transfusion

3. Did the child suffer from convulsions:

   A. (a) 1st day (b) later

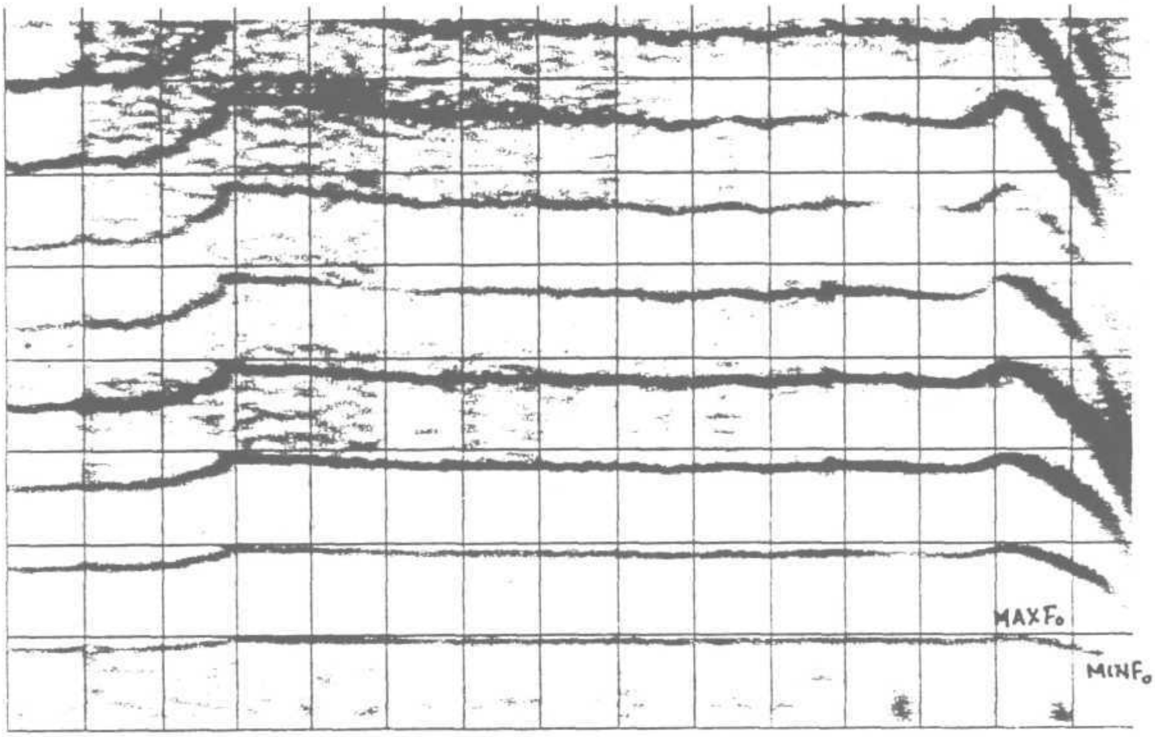
   B. Duration of convulsion

4. Congenital abnormality:

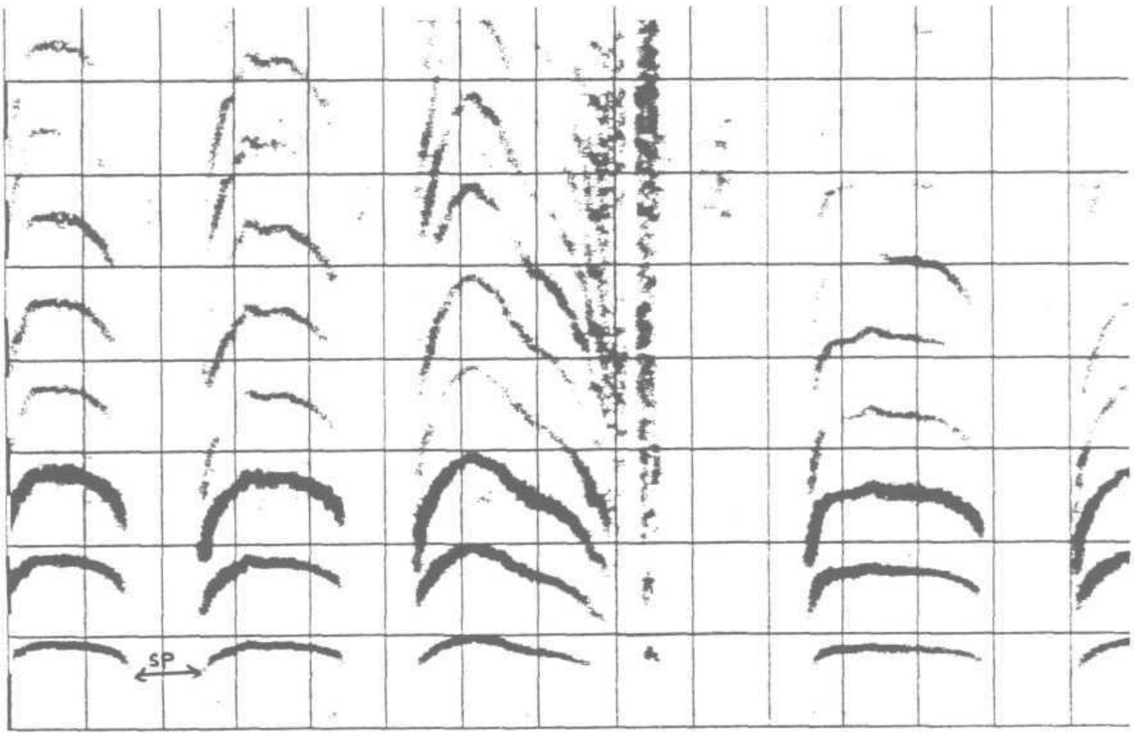
   a) Cranio facial anomolies
   b) Cleft Palate - sub mucus over:

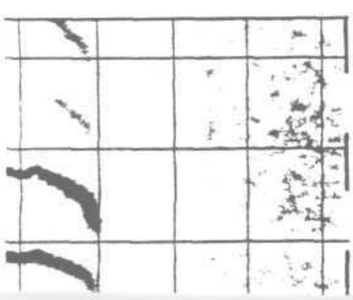
SPECTROGRAPHS SHOWING DIFFERENT CRY CHARACTERSTICS

APPENDIX D

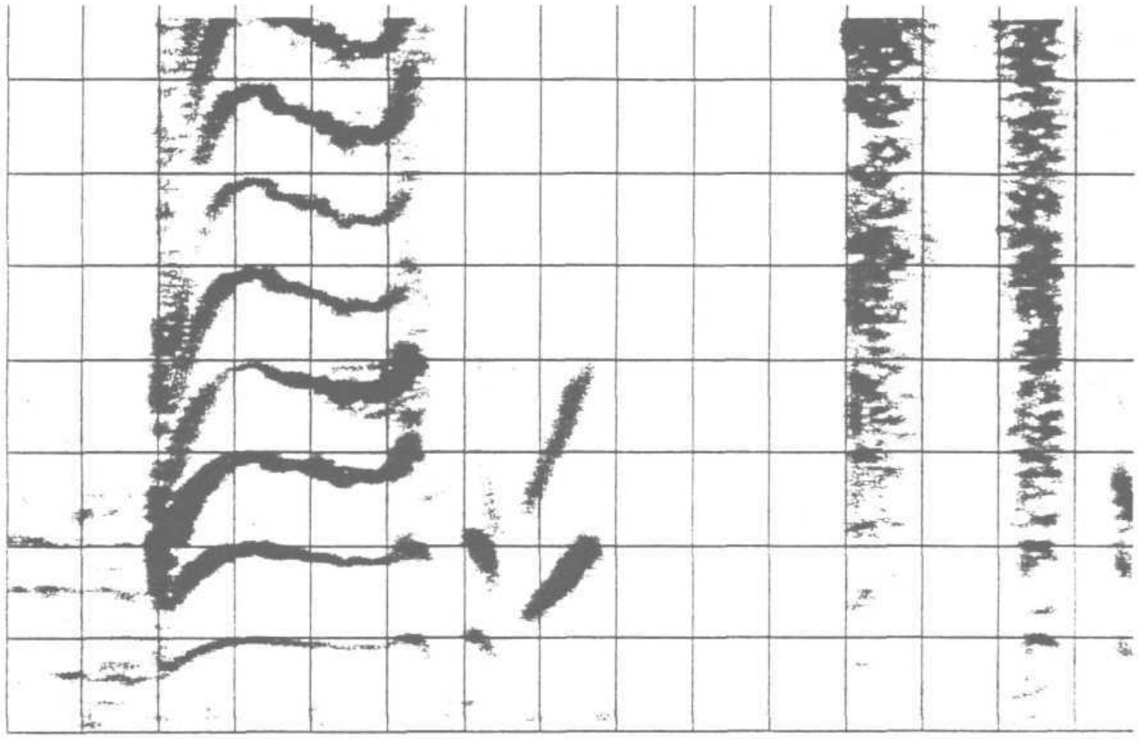


MINIMUM AND MAXIMUM F_0

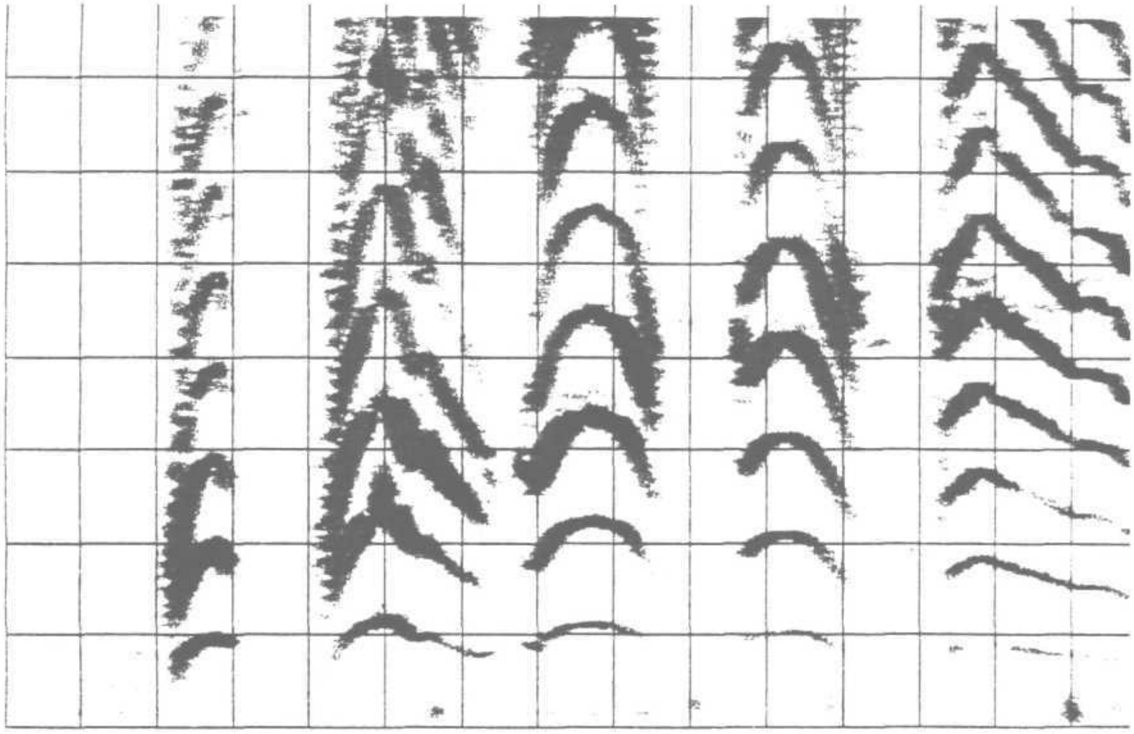




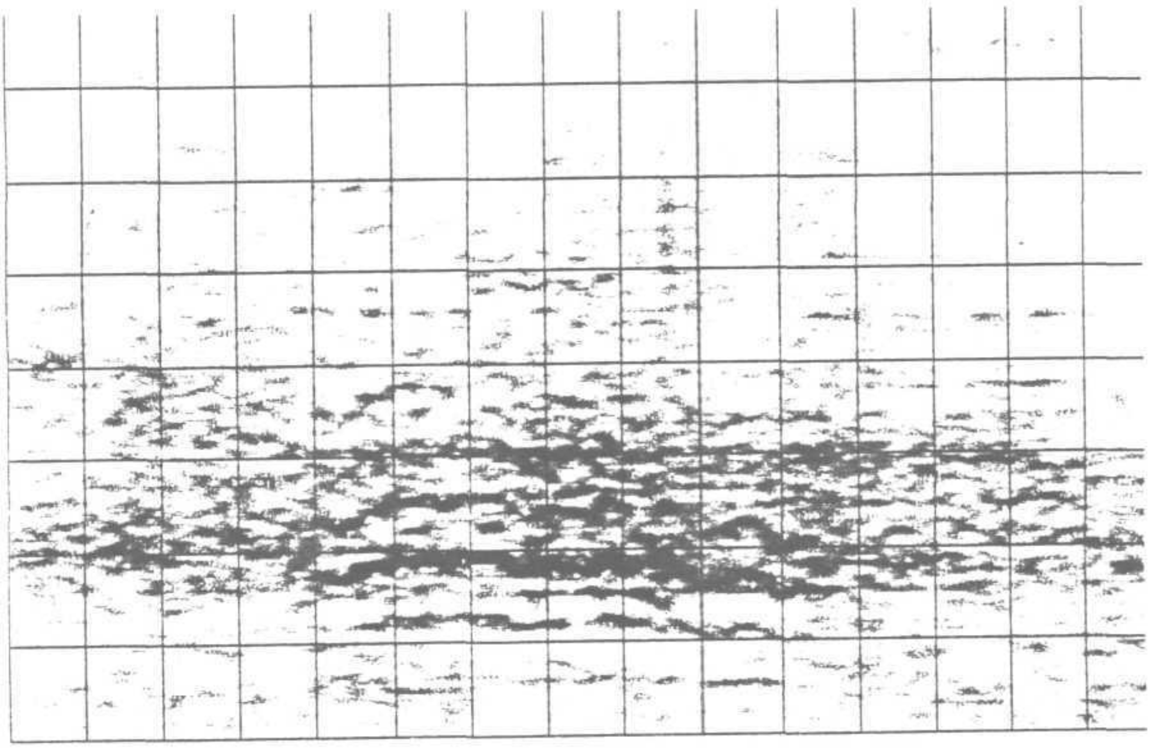
SECOND PAUSE



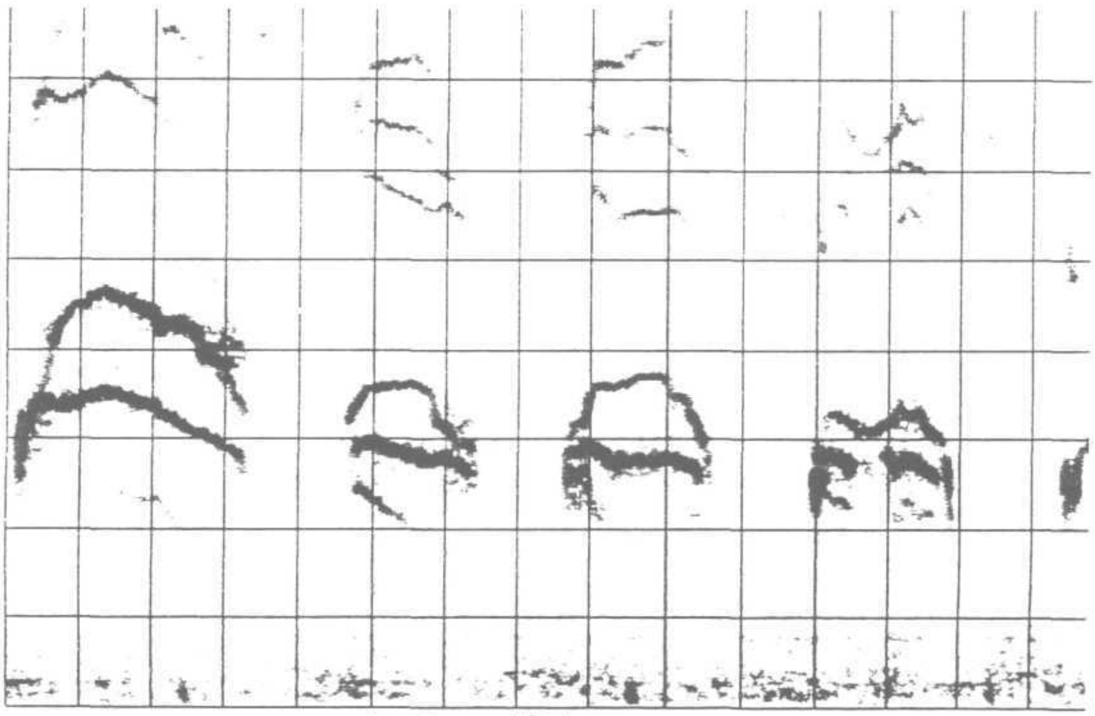
GLIDE



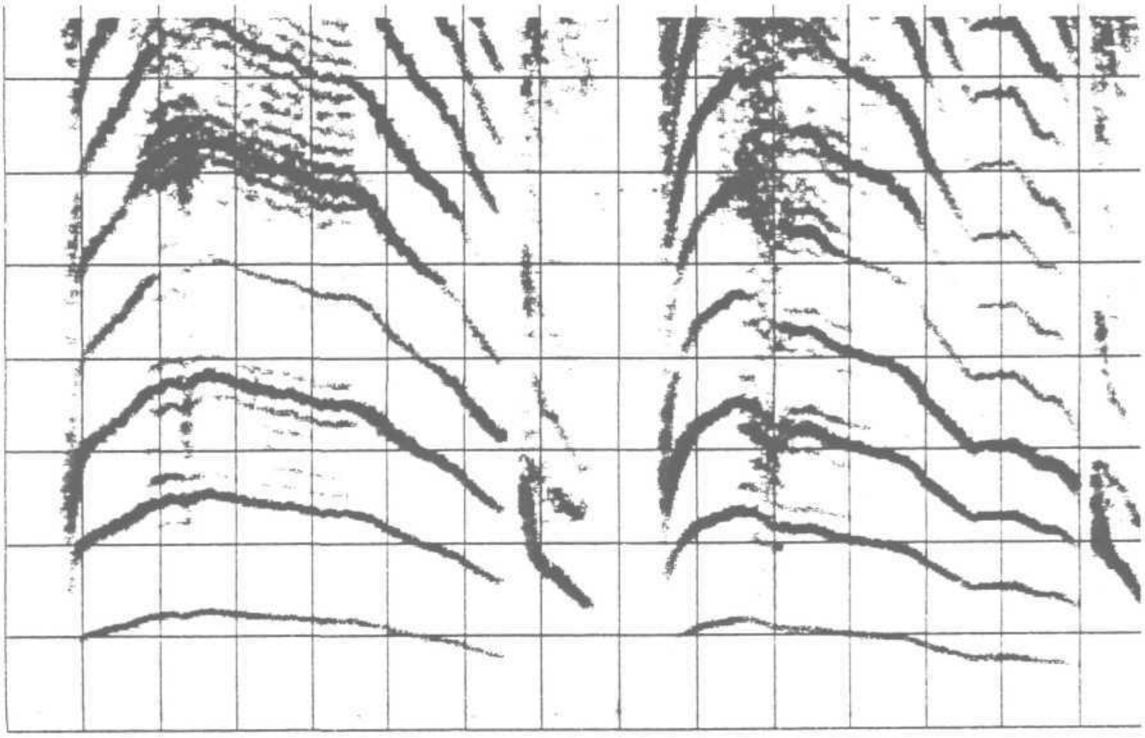
SHIFT



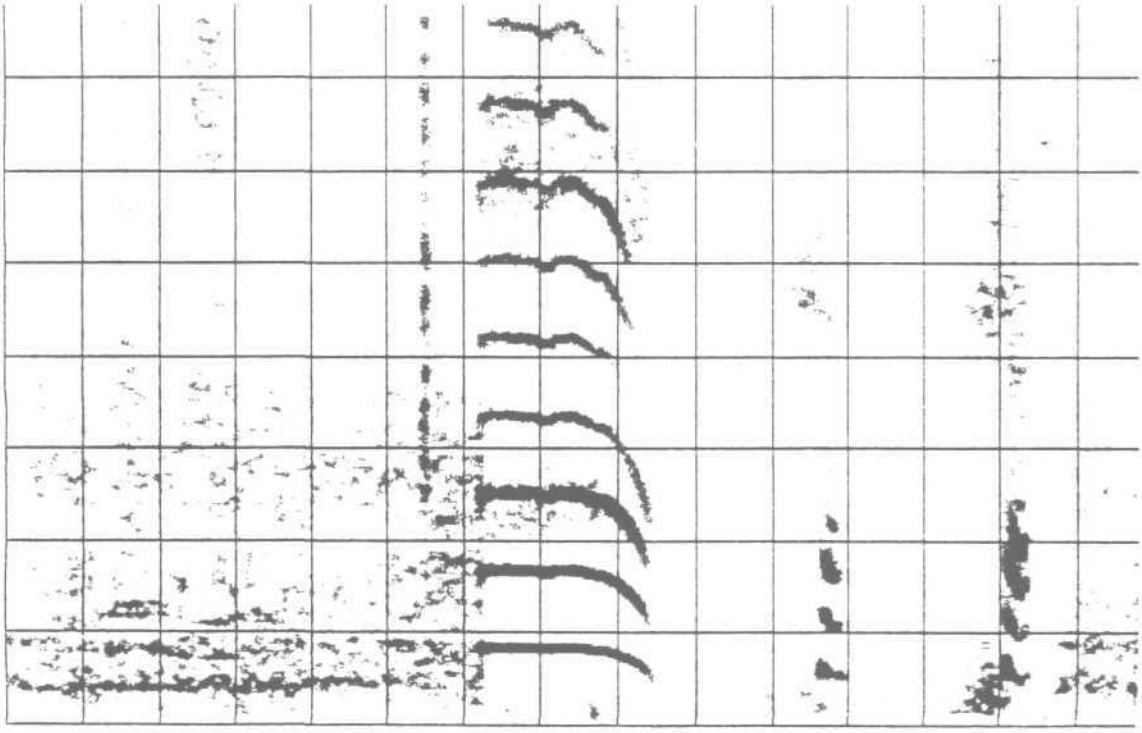
NOISE CONCENTRATION



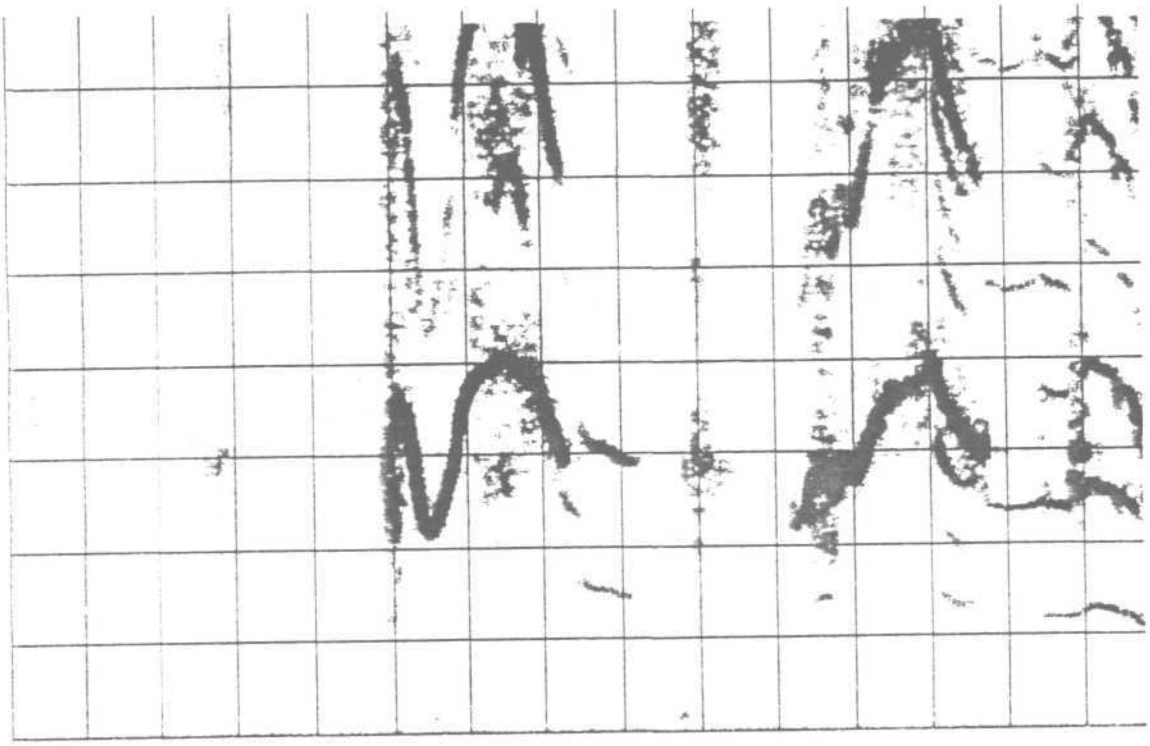
FURCATION



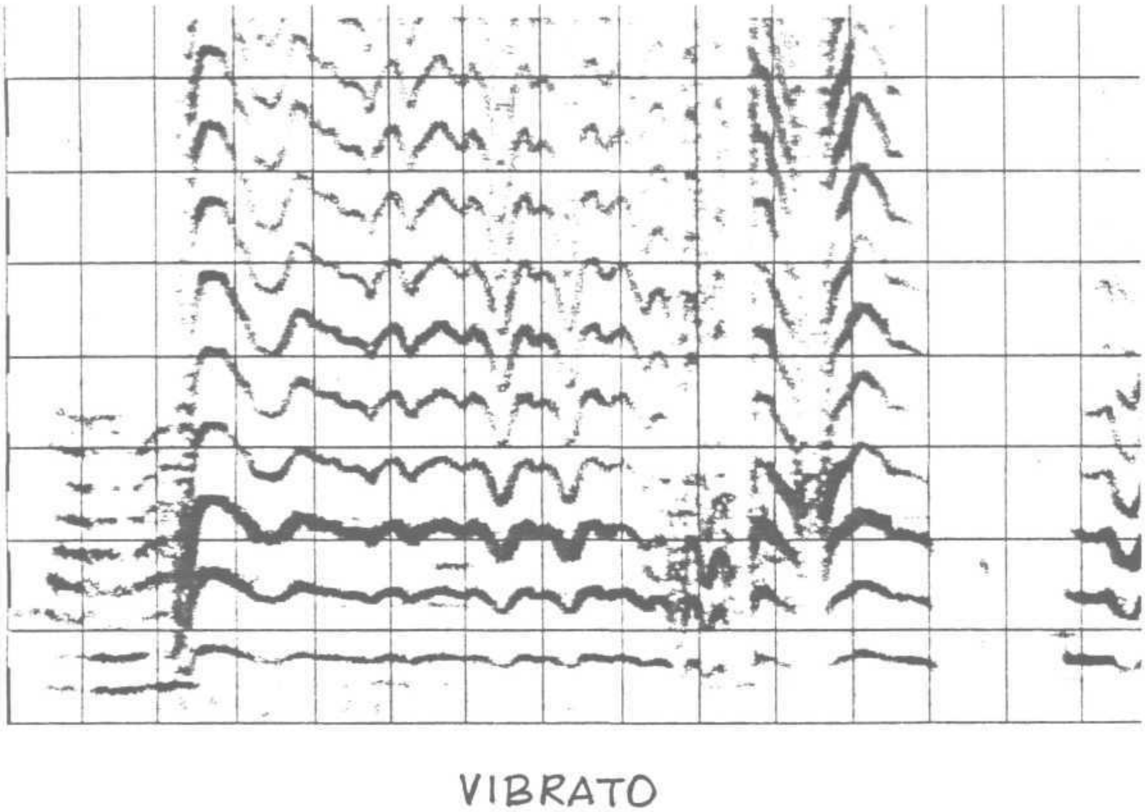
DOUBLE HARMONIC BREAK



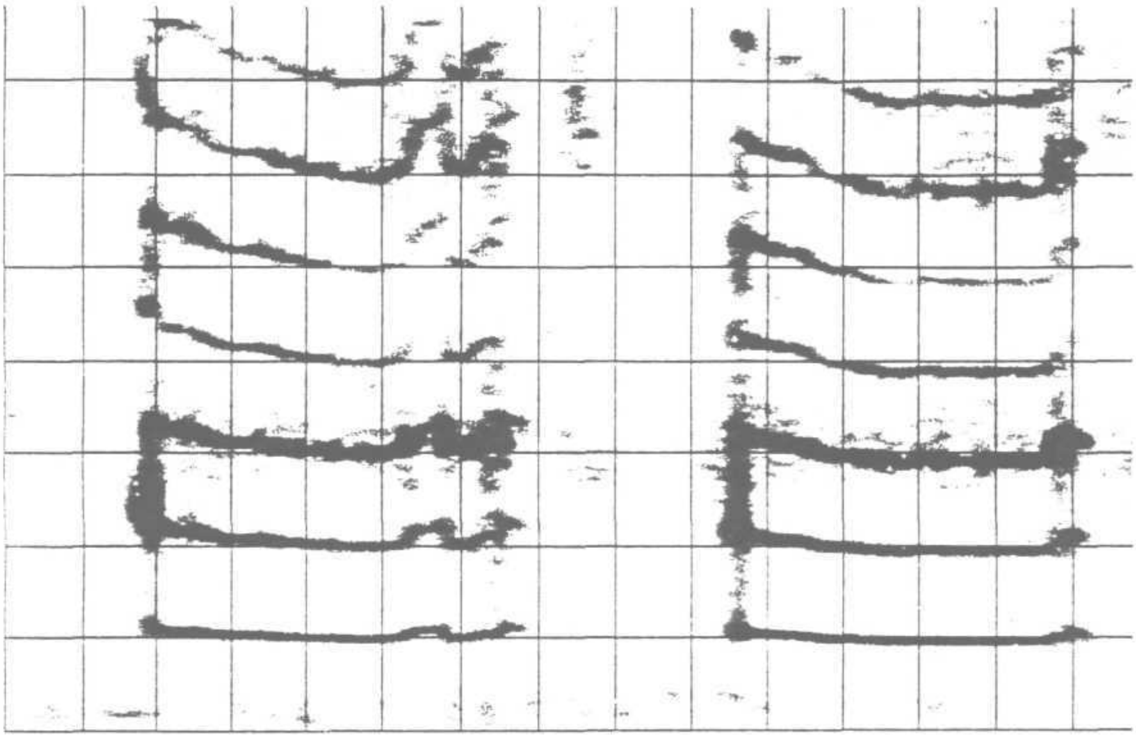
GLOTTAL PLOSIVE



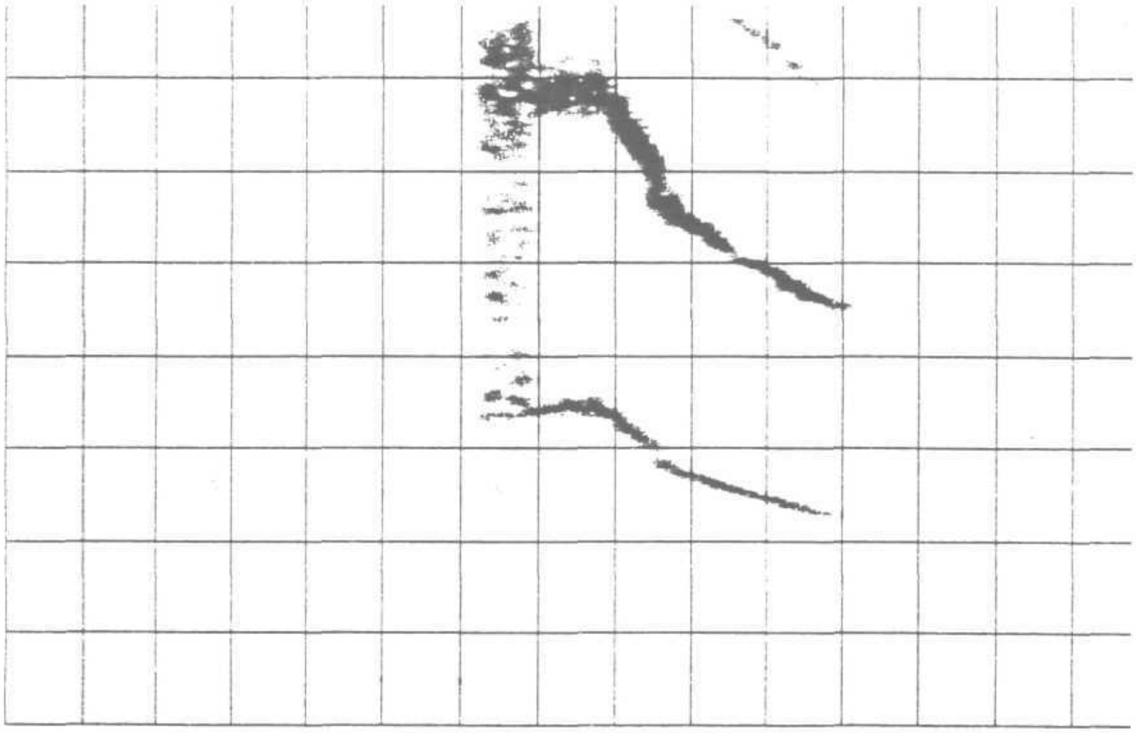
TONAL PIT



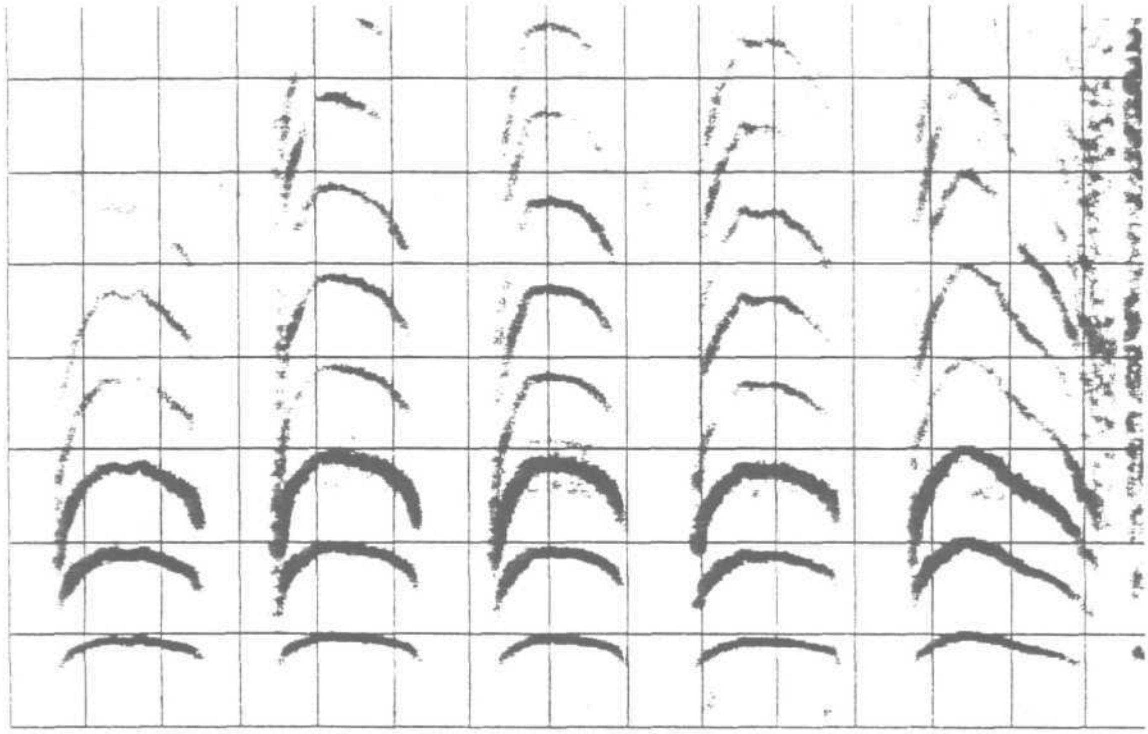
VIBRATO



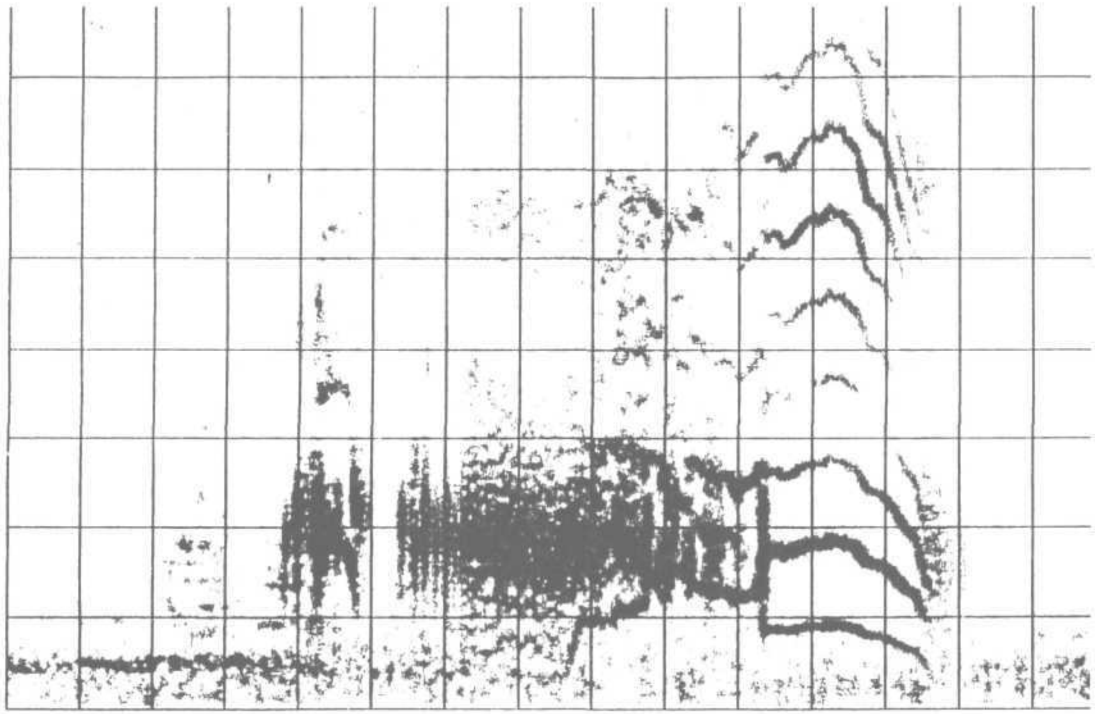
MELODY - FLAT TYPE



MELODY - FALLING TYPE



MELODY – RISING FALLING TYPE



BIPHONATION