Data Collection of Infant Cries for Research and Analysis

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Summary: Analysis of infants cries may help in identifying the needs of infants such as hunger, pain, sickness, etc and thereby develop a tool or possible mobile application that can help the parents in monitoring the needs of their infant. Analysis of cries of infants who are suffering from neurologic disorders and severe diseases, which can later on result in motor and mental handicap, may prove helpful in early diagnosis of pathologies and protect infants from such disorders. The development of an infant cry corpus is necessary for the analysis of infant cries and for the development of infant cry tools. Infant cry database is not available commercially for research, which limits the scope of research in this area. Because the cry characteristics changes with many factors such as reason for crying, infant's health and weight, age, etc, care is required while designing a corpus for a particular research application of infant cry analysis and classification. In this paper, the ideal characteristics of the corpus are proposed along with factors influencing infant cry characteristics, and experiences during data collection are shared. This study may help other researchers to build an infant cry corpus for their specific problem of study. Justification of the proposed characteristics is also given along with suitable examples.

Key Words: Infant cry–Spectrographic analysis–Cry modes–Cepstrum analysis–Database.

INTRODUCTION

Infant cry signal carries several levels of information, for example, reason for crying (hunger/pain/colic pain/discomfort due to wet diaper/loneliness), integration of vocal production system, maturity of respiratory system, language acquisition, and maturity of central nervous system (CNS). Numerous research has been done in the infant cry analysis from the viewpoint of parental perception of infant cry, developmental aspects of infants from their cry analysis, effects of various factors on infant cry patterning, etc.[1–5] In the medical domain, cry is studied to find out the acoustic features underlying the cry, to understand the possible causes of cry, and the effects of causes apparent in the cry. In the analysis of pain cries of newborns, it is observed that newborns modulate the supralaryngeal tract considerably following a painful stimulus than they would in spontaneous cries.[6] In invasive pain cry stimulus, the cry produced is rated as urgent by parents, and acoustic features such as high fundamental frequency (F_0), longer crying bouts, fewer harmonics, and greater variability of the F_0 are found.[7] In newborns, dysphonic cries show anger.[8] Along with it, newborn cries do not show much difference in the highest and lowest F_0, and there are no differences in the cry acoustics according to gender.[9] Gender-specific differences in F_0 and formant frequency patterns appear at the age of 11.[10] Cry has also been studied for the parents' perception of infant cry. It is shown in the past that mothers can recognize their infants from their cries. However, recent studies show that fathers are as good as mothers in recognizing their newborn's cries, and it depends on the time spent with the infant by parents.[11] The perception of cry from parents is reflected in the parenting depending upon how parents perceive the underlying message sent through the cry signal. Cry draws the attention of the parents when it is different. Parents' response to the infants' cry depends on the cry acoustics (F_0, changes in F_0 [ie, intonation pattern], loudness, duration, rhythm, etc.), psychological makeup, and living conditions of the parents. Negative response or no response to infant cries may result in child abuse.[12] Another study[13] reported that the synchrony of arousal between infant and caregiver results in changes in the neurobehavioral mechanisms, and the changes in the intensity of arousal are reflected in graded and dynamic acoustic signal. Deviations in the cry signal are noticed by the parents, and misunderstanding these deviations may compromise infant care and parental effectiveness.[14] Moreover, in the same study, it is reported that the infants with abnormal cries should be referred for full neurologic evaluation. Infant crying in the early 3 months of age is a signal of vigor that is evolved to reestablishment of parental contact.[15]

Research in infant cry analysis using signal processing methods such as spectrograms was started by a team of Scandinavian researchers in 1960 (Lester, et al.). In the initial two decades, the cry analysis used mainly the spectrographic analysis.[16] The infant cry signal has been studied mostly by the researchers from the medical field and those who study the development of infants. In the medical field, infant cry has been analyzed for identifying the features particular to a pathology. Most of the work done in this direction is the classification of normal and deaf infants, asphyxiated infants, and those who suffer from heart-related diseases. Another discipline where infant cries are studied is the behavioral sciences.[17] In this field, the cry pattern is analyzed to see the effect of parents and infants relationship under various conditions such as parents' literacy, response of parents to infants' cries, possible use of nicotine during pregnancy, etc.[18] Linguists also use the cry signal analysis for studying language acquisition by the infants and studying the effects of multilingual atmosphere on child's learning.[19] Interestingly, language acquisition also plays an important role in designing of speech

robots. Furthermore, contribution is also made by the engineering field in this area.

Nowadays, engineering professionals are showing interest to develop an infant cry analyzer, signal processing algorithms, and classification of pathologic infant cries from normal infant cries. In this direction, work has been done toward classification and analysis of infant cry types (hunger, pain, and pleasure cries), and classification of pathologic cries where different set of pathologies were considered by different researchers.[20–25] However, there is little work performed in the field of infant cry analysis and classification.

Infant cry analysis is also important for the identification of the infants who are susceptible to sudden infant death syndrome (SIDS). SIDS is the condition of infant death where the reason of death remains unanswered even after a thorough medical examination and autopsy. Sudden unexpected death in infancy (SUDI) or sudden unexpected infant deaths (SUID) are also used as synonyms to SIDS. Distinction between SIDS and SUID is generally difficult. Most of the SIDS deaths occur during 2–6 months of age. The chance of deaths due to SIDS reduces after 1 year of age. It has been reported by parents of the SIDS victims that the cries of their infants are strange or different from their siblings and other normal infants. Stark and Nathanson studied the cries of a male infant who died at the age of 6 months. They found that compared with normal infants, the infant cries were shorter and weaker. Colton and Steinschneider reported the cry characteristics of a female infant who died at the age of 63 days and reported that the F_0 was lower, duration was longer, and sound pressure level was higher than the normal infants group and SIDS siblings group.[26] Infants who die of SIDS have abnormalities in the brain stem, which helps to control functions like breathing, blood pressure, and arousal, and abnormalities in serotonin signaling.[27]

The main challenge in the infant cry analysis and classification is the unavailability of a statistically meaningful database (or at least sufficiently large number of infant cry samples). Collecting a database requires permissions from the hospital authorities and parents as well. Getting pathologic cry signals of infants who are suffering from some disease is furthermore difficult. Getting a statistically significant data is a challenging task. Most of the researchers working in this area have their own database with different sets of infant cry types, recording conditions, age groups, different pathologies, and different weights of infants. A standard database for the task is not available, which also restricts the comparison of different research works. Cry signal characteristics change with several factors such as reason for crying, age of the infant, etc. For example, birth cry cannot be mixed with other cry types because it is a response of the infant to exposure to air atmosphere from fluid atmosphere. It is an indicator of proper functioning of the infant's respiratory system. Therefore, the first cry has distinct F_0 which is different from the rate of vibration of vocal folds due to poor neural control of CNS over vocal system. However, there is turbulent noise present due to nonlinear interaction of the vocal excitation source and system. In pathologic cry analysis, cry characteristics change with the severity of the disease. In such cases, long-term follow-up of the infant is required, which is a

difficult task. All these effects altogether pose challenge to the researchers to work in this area and contribute toward it. In this paper, the effects of these factors on the infant cry analysis are given, and a guide for data collection is suggested so that the researchers who are interested to work in this area can collect their data accordingly and design their corpus which can be used potentially in their research work. This study will help in possible standardization of infant cry corpus preparation. The paper is organized as follows: Section 2 describes the ethical issues in infant cry data collection and protection of human rights. Section 3 gives details of metadata preparation, and ideal characteristics of infant cry corpus are listed in Section 4. Experiences during data collection and details of database collected are reported in Section 5 and Section 6, respectively. Illustration of several factors influencing the cry characteristics are given in Section 7, and the paper is summarized in Section 8.

ETHICAL ISSUES IN INFANT CRY DATA COLLECTION AND PROTECTION OF HUMAN RIGHTS

Infant cry recording is a very sensitive task that involves dealing with newborn human participants. Researchers have considered pain cry and hunger cry for infant cry analysis. To record the pain cry, how stimulation should be given to the infants has been an issue of debate for a long time. In the medical domain, pain cry is recorded by giving a rubber snap on an infant's foot. As long as this is done by a medical practitioner, parents generally do not object. However, for others, they do not allow it to be performed on their child. Even hospital authorities also do not allow using such practice for data collection purpose. Data collection of pain cry is possible only during *immunization process* or during treatment if injection is given. There are several advantages of data collection of pain cries during the immunization process, such as the following: the amount of stimulation is controlled (which is not the case in other methods), cries collected are from the same age groups as for a particular vaccine, specific age is defined, and generally, in immunization units, silence is maintained. Recording of hunger cry is even more difficult. For data collection of hunger cry, the only option is to wait until the infant gets hungry. Another important issue is to convince the parents for the purpose of data collection and getting their approval. For normal infants, this part is comparatively easy. However, for infants who are sick, especially those who have severe pathologies, this task becomes very difficult. In these cases, emotional status of the parents should be considered, and all their decisions, even if these are not positive for data collection, should be respected without hurting their sentiments.

To look into these sensitive issues such as the method of cry stimulation and protection of human rights, the Institutional Ethics Committee (IEC) is formed by hospital authorities. The objective of the IEC is to ensure a competent and consistent ethical review mechanism for health and biomedical research proposals dealt by the committee as prescribed by the ethical guidelines for biomedical research on human participants (Indian Council of Medical Research[28] in India or Council for International Organizations of Medical Sciences and World Health Organization guidelines[29] or respective country's guidelines). The ethical committee ensures that the procedures used for scientific research