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Phonation in the newborn, infant cry

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Abstract

Sound spectrographic studies have shown that the crying of newborn infants has a fundamental frequency of about 400–600 cycles per second, and mostly a slightly rising–falling melody contour. In sick infants, and especially those with diseases affecting the central nervous system, abnormal cry characteristics occur. The fundamental frequency has been increased, and the melody contour is unstable. Various cry characteristics, which rarely occur in cries of healthy infants, are more often present in cries of the sick ones. Studies of cries in newborn infants have been especially aimed to determine whether cry analysis could be successful in diagnostics and in the early detection of the infant at risk for developmental difficulties. © 1999 Elsevier Science Ireland Ltd. All rights reserved.

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1. Introduction

Crying is the newborn infant's only mode to express his needs and feelings to the caregiving environment. The cry is thus regarded as important for survival. It is not only strong, but also has acoustic properties that elicit maximal attention in adults regarding love and care, and also irritation and anger.

Biologically significant sounds are characterized as discrete or graded. Discrete signals operate in an on–off manner and have little variation in intensity and duration, while graded signals are more variable and change with the motivational state of the signaller [1]. The newborn cry has been described as discrete with two types, pain and non-pain. A non-pain cry is most often interpreted by the parents as hunger. However, feeding the infant gives also an opportunity for eye-contact and social interaction.

As the infant develops, the non-pain cries become differentiated and signal different needs. Thus, crying is the beginning of human vocal communication.

2. Cry research

Research on baby cries has been ongoing since the last century and can be dealt with from many different perspectives, such as anatomical, physiological, psychological, phonetic, or pediatric.

The first studies on infant cries were mainly based on auditory identification of various cries.

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Progress in cry research was maintained by the development of equipment for permanent recording of sound. The first apparatus for this purpose were the graphophone and the gramophone one hundred years ago. The development of tape recorders in the 1920s and the sound spectrograph in the 1940s forwarded research on baby crying. Nowadays, computer-assisted signal-processing methods are commonly used.

Systematic studies of baby cry began in the 1960s, and most of it was carried out in Helsinki, Finland [2–5]. These studies were based on sound spectrographic analysis of the cries of newborn and small infants, both healthy and those with various diseases.

3. Baby cries

Crying in the human infant is a complex phenomenon occuring during the expiratory phase of respiration, and includes the production of sound of the vocal folds. Crying presupposes functioning of the respiratory, laryngeal and supralaryngeal muscles. The central nervous system (CNS) controls the capacity, stability and co-ordination of the movements in these muscles. Hence, the cry provides information about how the CNS is functioning.

The cry sound is produced by vibrations of the vocal folds in the larynx. The number of times the sound wave repeats itself during a second is the fundamental frequency (cycles per second (cps), Hz), and is what we hear as voice pitch. The higher the frequency, the more shrill the sound. The vocal tract modifies the sound generated at the larynx, producing resonance frequencies or formants.

4. Cry characteristics

When our research group in Helsinki started with sound spectrographic cry analysis, there was no information available on what to measure from the 'cry-prints', the sonagrams. Thus, the definitions of the various cry characteristics were developed by the research group [2–4]. These

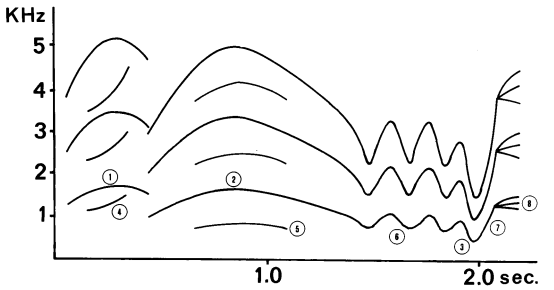

Fig. 1. Schematic diagram of a sound spectrogram: (1) shift and maximum fundamental frequency of shift, (2) maximum value of main fundamental frequency, (3) minimum value of the fundamental, (4) biphonation, (5) double harmonic break, (6) vibrato, (7) glide, and (8) furcation.

attributes concerned either durational or fundamental frequency characteristics (Fig. 1). We measured the duration of the cries and the latency period, i.e. the time between pain stimulus and onset of crying. Also, the melody contour was studied. The fundamental frequency characteristics comprised the mean, maximum and minimum values of the cries. We also noted other attributes, such as biphonation, shift (sudden changes in the fundamental), and glide (rapid variations in the fundamental).

5. Cry in healthy newborn infants

The mean fundamental frequency of cries of newborn and small infants has been found to vary between 400 and 600 cps (Fig. 2) [2,3,5–10]. In a recent study by Michelsson et al. (unpublished),

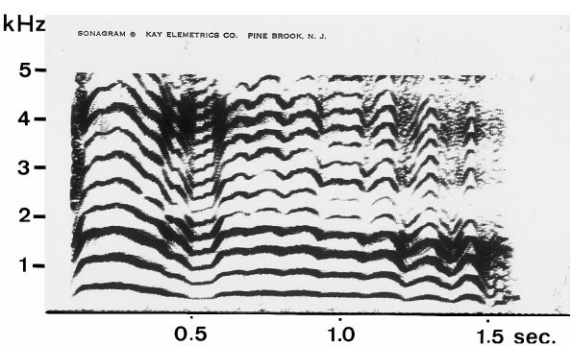

Fig. 2. Cry of a healthy full-term newborn infant.

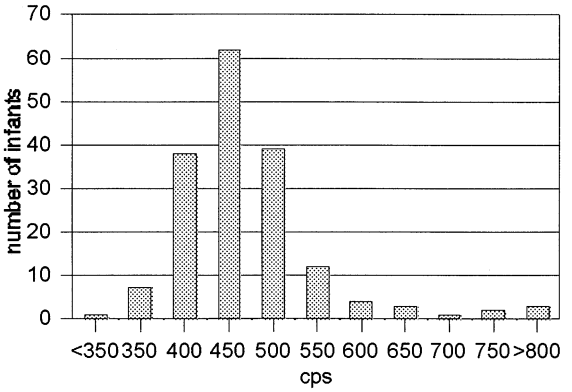

Fig. 3. Mean fundamental frequency in cries of 172 infants.

the mean fundamental of 1836 pain cries of 172 infants was 496 cps. From each infant, 8–15 cries were analysed. The mean of these cries was above 700 cps in 3% of the cases (Fig. 3). In most cries of healthy infants, the melody contour is falling or rising–falling. Shifts and glide are rare. Shifts occur more often in pain than in spontaneous cries [2].

It is generally thought that the newborn is capable of producing two types of cries: a pain cry and a non-pain cry, which most frequently is heard when the infant is hungry, but also at other times [11]. These cry types have been distinguished in sound spectrographic studies [2] and also audiotorily (tape sample 1 available from author).

6. Cry in sick infants

Studies of crying of infants with diseases were carried out mainly in the 1960s. The aim was to evaluate whether specific cry features existed for specific disorders. Hence, cry analysis could be useful in medical diagnostics.

Variations in cry characteristics were documented in a number of medical abnormalities, including Cri du Chat syndrome, Down's syndrome, hyperbilirubinemia, encephalitis, meningitis, asphyxia, as well as various forms of brain damage (Figs. 4–6; tape sample 2 available from author) [2,3,5]. Abnormal cry characteristics have also been associated with factors occurring during risk pregnancies, which place the infants at risk for later handicaps, such as premature birth and the mother's use of narcotics [1,11].

The fundamental frequency has been increased in prematurely born infants; the more immature the baby, the higher the pitch [12]. The fundamental frequency of cries has also been found to increase, especially in babies with diseases affecting the CNS. In the cries of these infants, other cry characteristics have also changed from the normal configuration, such as the melody contour and the occurrence of shift, biphonation and glide.

The more severely sick the infant, the more abnormal cry characteristics have been documented. Abnormal cry characteristics have appeared for a longer period of time in infants who

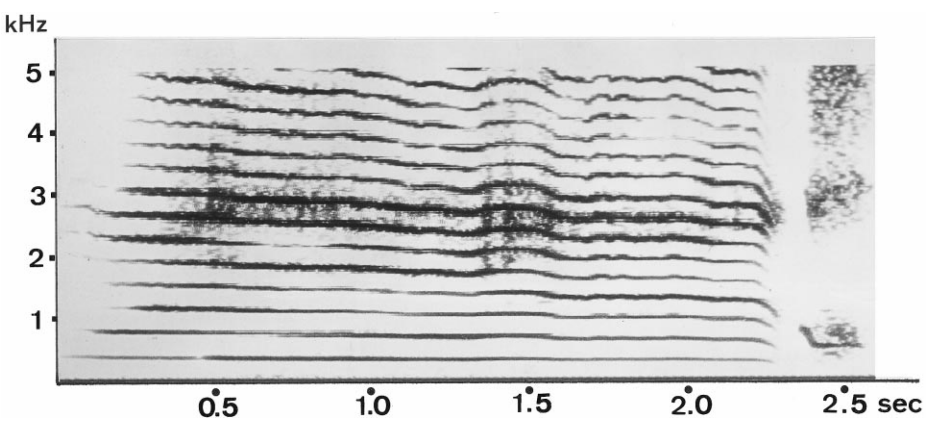

Fig. 4. Cry of an infant with hypothyroidism.

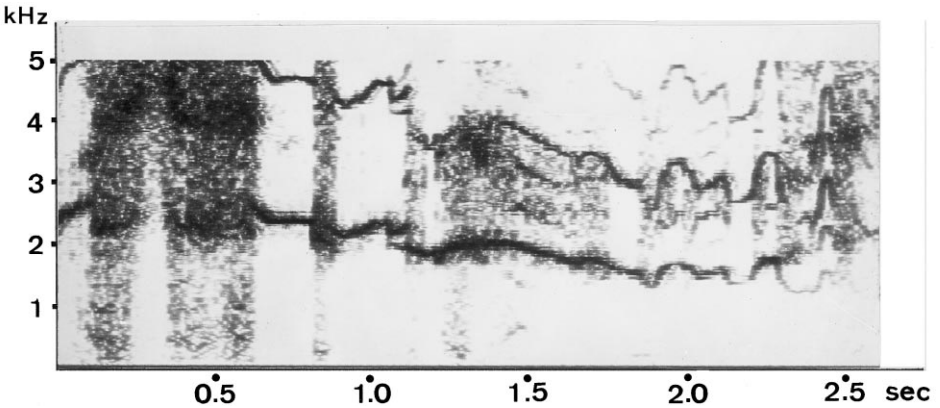

Fig. 5. Cry of a 2-day-old infant with severe asphyxia at birth.

at later follow-up have been found to be severely handicapped [13].

7. Clinical diagnostics

Studies of cry characteristics in the newborn infant were aimed to determine if cry analysis could be succesful in the early detection of the infant at risk for developmental difficulties. This is expected as cry analysis reflects the function of the CNS. The most abnormal cries have been found in infants with CNS disturbances. Thus, abnormal cries provide suspicion of CNS involvement, and is helpful in conjunction with other information when assessing diagnosis. For example, if a newborn is diagnosed with cerebral haemorrhage, we would be more worried if the cry was abnormal than if it was normal. Alternatively, if an infant who appears normal on routine pediatric examintaion has an abnormal cry, he/she warrants more careful attention.

An abnormal cry may be a transient sign but may also indicate a more serious underlying problem. An abnormal cry may draw the attention of an adult and lead to a detailed observation of the infant. Thus, probable impairments may be diagnosed and medical intervention started. However, much research is still needed before specific cry characteristics can be combined with specific diseases. Nevertheless, any diagnostic method that can be valuable in the newborn period should be further developed. Additionally, cry analysis gives diagnostic information without invasive pain causing procedures.

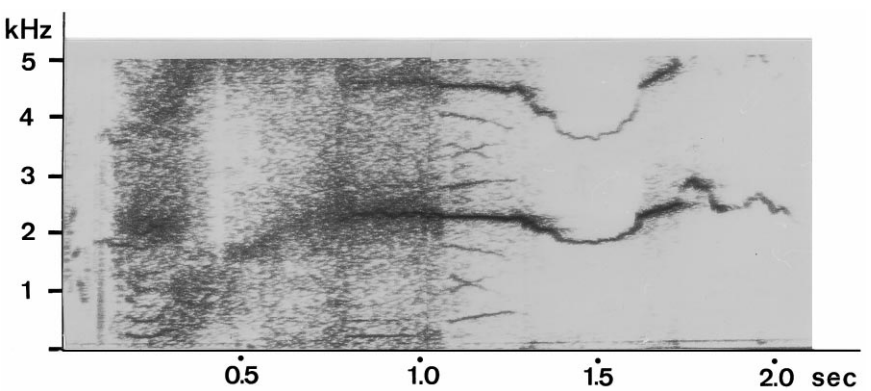

Fig. 6. Cry of a 4-month-old infant with meningitis.

References

[1] B.M. Lester, C.F.Z. Boukydis, No language but a cry, in: H. Papousek, U. Jürgens, M. Papousek (Eds.), Nonverbal Vocal Communication. Comparative and Developmental Approaches, Cambridge University Press, Cambridge, 1992.

[2] O. Wasz-Höckert, J. Lind, V. Vuorenkoski, T. Partanen, E. Valanne, The infant cry. A spectrographic and auditory analysis, Clin. Dev. Med. 29 (1968) 1–42.

[3] K. Michelsson, Cry analyses of symptomless low birth weight neonates and of asphyxiated newborn infants, Acta Paediatr. Scand. Suppl. 216 (1971) 1–45.

[4] P. Sirviö, K. Michelsson, Sound-spectrographic cry analysis of normal and abnormal newborn infants, Folia Phoniatr. 28 (1976) 161–173.

[5] K. Michelsson, O. Wasz-Höckert, The value of cry analysis in neonatology and early infancy, in: T. Murry, J. Murry (Eds.), Infant Communication: Cry and Early Speech, College Hill Press, Houston, TX, 1980, pp. 152–182.

[6] C.-J. Thodén, M. Koivisto, Acoustic analysis of the normal pain cry, in: T. Murry, J. Murry (Eds.), Infant Communication; Cry and Early Speech, College Hill Press, Houston, TX, 1980, pp. 124–151.

[7] R.L. Ringel, D.D. Kluppel, Neonatal crying: a normative study, Folia Phoniatr. 16 (1964) 1–9.

[8] T. Murry, P. Amundson, H. Hollien, Acoustical characteristics of infant cries: fundamental frequency, J. Child Lang. 4 (1977) 321–328.

[9] G. Kittel, L. Hecht, Der erste Schrei-frequenzanalytische Untersuchungen, Sprache Stimme Gehör 1 (1977) 151–155.

[10] K. Michelsson, K. Christensson, H. Rothgänger, J. Winberg, Crying in separated and non-separated newborns; sound spectrographic analysis, Acta Paediatr. 85 (1996) 471–475.

[11] P.S. Zeskind, B.M. Lester, Acoustic features and auditory perceptions of the cries of newborns with prenatal and perinatal complications, Child Dev. 49 (1978) 580–589.

[12] K. Michelsson, A.-L. Järvenpää, A. Rinne, Sound spectrographic analysis of pain cry in preterm infants, Early Human Dev. 8 (1983) 141–149.

[13] K. Michelsson, P. Sirviö, O. Wasz-Höckert, Pain cry in full-term asphyxiated newborn infants correlated with late findings, Acta Paediatr. Scand. 66 (1977) 611–616.