*hearing defect, voice examination*
*nasality processor*

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# „NASALITY" PROCESSOR APPLICATION FOR CHILDREN EXAMINATION WITH IMPAIRED HEARING SYSTEM

The paper presents a new method of diagnosis and therapy of nasality process, based on two computer attachments, used for visualisation of speech signals analysis. All kinds of nasality: closed, opened and mixed, were taken under consideration. In this article the Nasality Processor application was presented. Works have been illustrated by examples of statements, voiced by children with significantly or deeply impaired reception of a hearing system. The experimental works were discussed, explaining the nasality processes, carried out on statistically important group of children with hearing defects. Based on this research approach the new method of diagnosis and children voice rehabilitation, with oral problems, has been proposed. It concerns the right nasal resonance category that corrects or removes the nasality diseases.

## 1. INTRODUCTION

As a result of limitation or lack of hearing control of children with hearing defects and voice disturbances the audiogenic dysphonic has been invented. The specific conditions of larynx are strengthening. Nasality process is directly connected with tone and timbre of voice. This phenomenon is an after-effect of defective nasal resonance that is hard to eliminate in the case of hearing control lack. Three forms of nasality are distinguished: closed, opened and mixed (ex. [4]). The nasality problem in the case of children with impaired hearing system is very difficult to diagnose because in their phonological system nasal sounds very often do not exist. In that case, for the obvious reason, there is either diagnosis opportunity or the nasality process observation (ex. [3]). For the research investigations, which are presented in this paper, a group of deaf children from a primary school intentionally was chosen; which suffer from nasal sounds defects in their phonological system. In the presented paper first, the phonatory standards of nasality were exploited and verified (ex. [4]). Hence toning of sound „m" like „b" or „n" like „d" in the children voice was regarded as recognised nasality. The only solution was classification of the correctness of nasal sounds „ę" and „ą", as inflectional in some phonological contexts, characteristic of children with hearing defects. The research investigations have been performed with the support a computer attachment, called Nasality Processor. It has got an input in the form of an electrode, which is put on the person nose and is working like an accelerator. The collected speech signal when the air flow through the nose was presented,

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as the clearly changeable red curve, signed with NxAcc, is visible at the computer screen. Its amplitude depends on the speed velocity changes of the nose exterior parts movements in a unit of time. If the sound is more nasal, then the corresponding amplitude of vibration is higher.

## 2. THE AIM OF THE RESEARCH INVESTIGATIONS

The research were carried out on the group of children from 1-6 special school classes, at the age of 7-13, with significant or deep, bilateral, hearing defect, which become deaf just after or even before born. The aim of the research was the nasality phenomena study with support of Nasality Processor and practical verification of it usefulness in diagnosis process.

The works material was taken from a group of 88 children with significant (23%) or deep (77%), bilateral, hearing defects, receiver type, which are using hearing apparatus and learning at the special primary school. However the comparative group consisted of 25 healthy children, at the same age range as the deaf level. Children were put to the test by means of special experimental equipment for the speech signal visualisation, consisted of two computer interfaces – the Laryngograph Processor PCLX attachment and Nasality Processor. Computer-operated research post was made by joining the two earlier mentioned computer attachments to the computer. The first of them, Laryngograph, was based on electroglottography. Two electrodes are placed on both sides of the throat at the larynx level. The computer screen shows vibrations of vocal folds (waveform Lx in Fig. 1) and the basic frequency of this process (waveform Fx in Fig. 1). A separate part of the Laryngograph, namely a microphone, gives the signal which shows changes in the acoustic wave in time (lines Sp in Fig. 1). These are oscillograms from which, through the analysis of visible changes of vocal wave amplitude in time, its basic acoustic properties, including sound and nasality may be calculated. However, this way of presentation, does not give full information about proper articulation of nasal phones by the examined person, possible nasality process and its character, as well as the dynamics of air flow through the nose channel, which influences the quality, including the colour of the voice (ex. [1]). All these possibilities are offered by the computer attachment called Nasality Processor. An electrode placed on nostrils is its inlet. The waveform generated by this electrode on computer screen shows the dynamics of the air flow through the nose of the examined person, by measuring nostrils vibrations, like an accelerator which measures changes of speed in time, i.e. the acceleration of nostrils movement (lines NxACC in Fig. 1) and enables to determine proper nasal phones production, including the work of glottis. Such an analysis of voice parameters enables to draw many practical diagnostic-therapeutic conclusions.

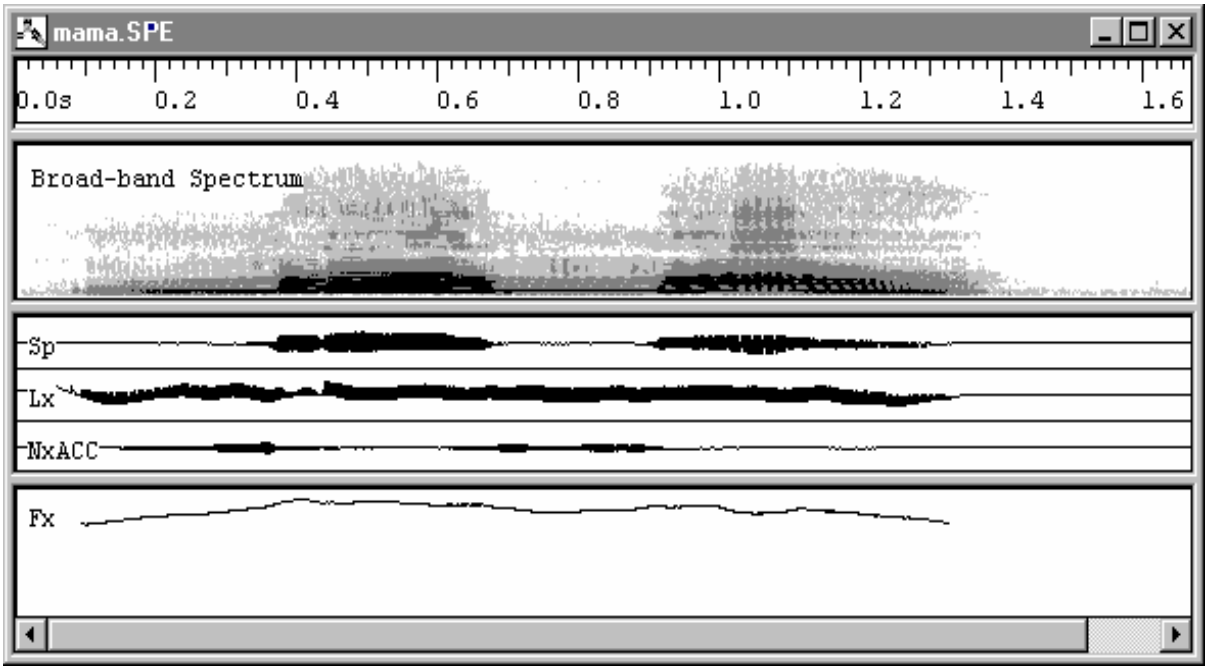


Fig. 1. Computer presentation of signal ‘mama’

The signals were stored in computer memory and next used for analysis by an integrated tool for speech tests named Speech Studio and QAnalyses program. This tool offers the complete analyze of stored statements and creating histograms, diagrams, and tables containing all the voice parameters of the examined person. The evaluation of nasality process was based on the analysis of NxAcc signal. The example is shown in Fig. 2.

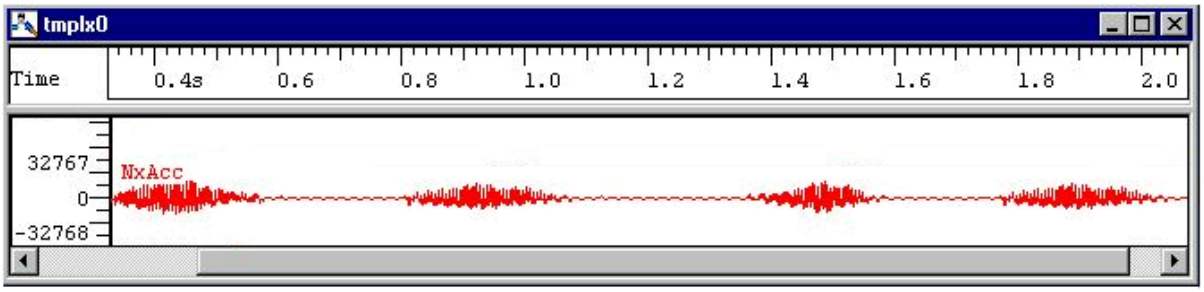


Fig. 2. Computer view of four statement „ma”, curve of nasal vibration changes in time, NxAcc

This is a view of the statement „ma”, which was said four times. In the Fig. there are clearly showed the increased values of the amplitude curve, corresponding to the air flow through the nose during speaking. Quantitative analysis of stored statements was possible to make with the support of the QAnalyses program. Results of this analysis contain the speech profiles for each examined person, in shape of diagrams, called Speech Pattern Elements. For the statement „mama” the received results are shown in Fig. 3.

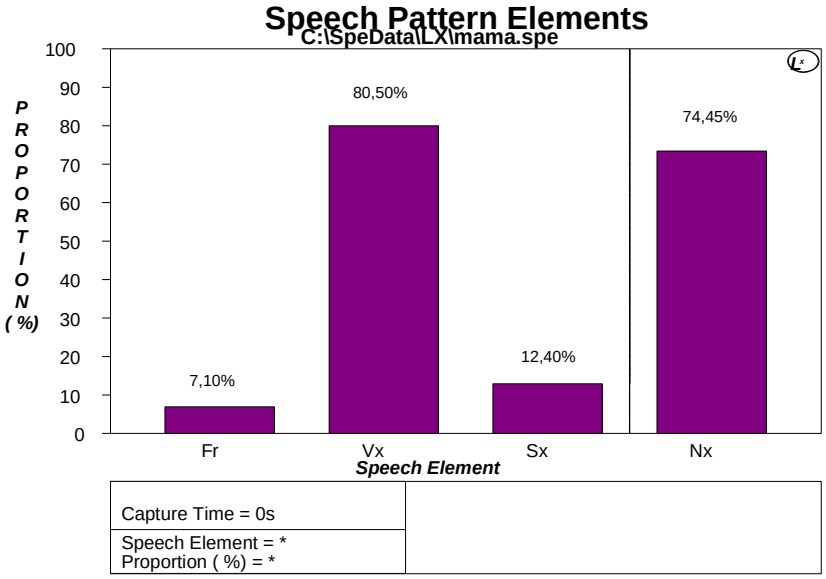


Fig. 3. Component elements analysis of the statement „mama", speech profile, example

This diagram consists of two independent parts, separated with vertical dashed line. Three first elements called Fr, Vx, Sx showed proportions between voiced oral statement (Vx), silence (Sx) and friction (Fr) elements. In total it is 100% of the statement composition. Vx represents the participation of the phonation voiced parts of the statement, created as the result of periodic (or almost periodic) work of vocal folds during articulation of voiced sounds. Fr element describes the turbulence phenomena and results from its friction, which arises during forcing air through the narrow voice ditch when voiceless sounds are articulated. The very important element Sx, which is visible in the diagram, is called silence. It enables to evaluate possible irregularities in dynamic breathing, breaks for inhalations and participation of voiceless in the statement. The most important, from the presented research point of view, is information about the air flow through the nose during speaking, which is signed as Nx in Fig. 2. When the material used for the examination is selected correctly then Nx value describes the kind and range of nasality process, if it takes place (ex. [2]).

## 3. RESULTS OF THE RESEARCH

Table 1 contains percentage results of the examination of nasality in the group of 88 children with significant or deep hearing defects, which have been achieved by means of integrated speech testing system Speech Studio. They revealed that opened nasality appeared only in 2% cases, at the other group appeared closed or mixed nasality almost in equal proportions (45%). The lack of evaluation occurred in 5%, when a child didn't make any articulated voice.

Table 1. Percentage results of the examination of nasality process in the group of children with hearing defects, n = 88

| Nasality kind | Percent of children |
|---|---|
| Proper | 5% |
| Closed | 42% |
| Mixed | 46% |
| Open | 2% |
| No evaluation | 5% |

Data showed in the next table have been received with the usage of analysing program called Qanalyses. Table 2 contains the average values, not related to those shown in Fig. 2, which have been achieved from the examination of speech elements, both deaf children and their hearing peers.

Table 2. Central values of speech elements

| | Phonation elements (voiced) | Friction (voiceless) | Brakes during speaking | Air flow through the nose |
|---|---|---|---|---|
| Deaf children | 42.07% | 12.94% | 44.99% | 33.30% |
| Hearing childrn | 75.02% | 6.07% | 18.91% | 70.50% |

The research, which has been performed, confirmed that during presentation of the same verbal material the air flow through the nose in the case of deaf children was two times smaller (33,3%) than in the case of healthy children (70,5%). Besides, the brakes during speaking appeared very often in case of deaf children. The inhalations took almost a half of time, which was assigned for their realisation (44,99%). The same parameter in the case of hearing children was two times smaller (about 19%). The research confirmed also that children with hearing defects have a tendency to voiceless voiced sounds. Phonation elements, that is voiced, amounted 75,92%, in the case of hearing children, however only 42,07% in the case of deaf ones. From the research point of view, very important results have been achieved in the case of air flow through the nose during speaking analysis which amounted 33,3% for deaf children and 70,5% for healthy ones. That proves that closed or mixed nasality appeared in most cases.

## 4. CONCLUSIONS

The presented research leads to the conclusion that the majority of children with impaired hearing system have symptoms characteristic of closed or mixed nasality. Opened nasality or the lack of evaluation is very rare. The diagnosed nasality had an active character and was caused by incorrect function of soft palate and by incorrect work of the clamping throat ring. Thanks to the preliminary research it was possible to plan and to perform the process of nasality removing by the process of voice breath rehabilitation and relaxation of flexed phonetic muscles. The research presented in this paper has included also the presentation of modern computer attachment Nasality Processor abilities, its usefulness in nasality diagnosis and revealed of the possibility the usage of this attachment in getting

correct, shifted higher, location of sound. It enables to achieve an active work of head resonator and relieve larynx and vocal folds during speaking. It enables also to ensure the same form and timbre of vowels, at the first articulation phase. It is also very important to notice that all these elements and nasality, in a significant way affects communication of statement because of their influence timbre, tone and strength of voice. These elements are very important to achieve intelligible, correct speech and communicative statements. However, they are very hard to work out in the case of children with impaired hearing system.

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