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OBJECTIVE CHARACTERISTICS OF THE VOICE OF PRIMARY SCHOOL CHILDREN WITH DYSARTHRIA

Abstract. The study is aimed at revealing objective voice characteristics of children with dysarthria using instrumental methods. The authors have examined 50 subjects aged 7 through 10 years with the diagnostic conclusion "GSU (general speech underdevelopment), speech development of level III" (GSU is caused by a spastic-paretic form of moderate dysarthria) and 20 subjects without speech disorders. The following voice function parameters of the children have been examined: fundamental tone frequency (FTF), voice power, maximum phonation time (MPT). A special speech visualization tool – the computer program PRAAT – was used for objective study of speech characteristics. The program allowed the experimenters to process oral speech, visualize speech signals, and perform speech segmentation. The experiment revealed the following objective indicators of voice disorders in primary school children with dysarthria: frequency range narrowed down towards low frequencies; difficulties in changing the voice power from quiet to loud and vice versa; reduced dynamic voice range; reduced phonic exhalation; difficulties in using intonation contours. Furthermore, the experimental study made it possible to discover connection between the low rates of the MPT and malformation of the pectoral-abdominal type of breathing. The data obtained demonstrate the necessity of purposive rehabilitation work in the system of logopedic support in order to overcome the revealed voice disorders of primary school children with dysarthria.

Keywords: dysarthria; junior schoolchildren; voice; acoustic parameters; objective research methods.

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Introduction

Children with various speech disorders often demonstrate voice disorders, which is reported by many scholars [1; 3; 13; 15; 16; 18; 19, etc.]. Thus, voice specificity in cases of rhinolalia is described in the works by T. N. Vorontsova, I. I. Ermakova, A. G. Ippolitova, etc. T. N. Vorontsova and I. I. Ermakova [5; 7] believe that open nasalization (nasal resonance producing a muffling effect on the voice) is the leading symptom of the given speech pathology. Cleft palate violates coordinated functioning of the resonators, and discoordinates the work of the system “pharynx – palate”, which gradually brings about vocal cords asymmetry leading to reduction of voice intensity – it becomes unmodulated and monotonous. The pathological state of the vocal apparatus is aggravated as a result of physiological and phonic respiration degradation. According to A. G. Ippolitova [9], voice nasalization in cases of rhinolalia is caused not by the anatomic abnormality as such, but by such compensatory consequences as improper position of the tongue, impairment of coordination between all parts of the peripheral vocal apparatus, and impaired mobility of the soft palate.

It is well known that stuttering impairs voice. According to L. I. Belyakova and E. A. D'yakova [2], muscle spasms (or “stuttering moments” [20, p. 37]) affect the voice quality, intensity and dynamic range, modulation, and may bring about dysphonia.

On the basis of her observations, V. I. Filimonova [23] revealed the specificity of the vocal function in preschoolers with stuttering in the form of reduced voice intensity, muffled voice and hoarseness. In addition, the author noted monotonous intonation in the speech of such children.

Singular studies of the acoustic parameters of stuttering children of different ages using a speech visualization tool on the basis of information technologies demonstrated narrowing of the fundamental tone frequency (FTF) and its going down towards lower frequencies in comparison to the norm; problems with smooth reduction of the voice loudness; and discoordination between breathing and phonation [21; 22].

Dysarthria, and especially in the form of spastic paresis, is the most widespread children's speech disorder [18]. The works of E. S. Almazova, L. V. Lopatina, E. M. Mastyukova, I. I. Panchenko, K. A. Semenova and other researchers report the presence of voice disorders in such children [1; 14; 15; 18; 19]. I. I. Panchenko referred shallow breathing, discoordination between breathing and phonation, voice weakness, its intensity exhaustion, absence of vocal modulations, and insignificance of sound pitch variability to the most typical voice disorders. The voice timbre of such children is defined as muffled, sometimes hoarse, monotonous, poorly modulated; the rhythmico-melodico-intonational aspect of speech, its intelligibility and articulacy are severely impaired.

On the basis of the study of voice impairments in children with latent dysarthria with the help of the programs of recognition and analysis of speech signal EDS, L. V. Lopatina [14] singled out in a number of children reduced, unstable, or, on the contrary, exceedingly high voice intensity; problems with keeping a certain pitch of the voice, and switching the FTF from low to high. The voice timbre of the majority of the children was aspirated, hoarse, muffled, nasal, guttural, suppressed, etc.

It is worthwhile to mention the study of M. V. Mokhotaeva [17], which was conducted with the help of the computer-assisted complex "Multi-speech" for investigation of acoustic parameters of the voice of junior schoolchildren with various forms of CP. The author argues that the voice quality of such children differs from the voice of the typical peers in the form of frequency and amplitude instability. Instability is associated with the unstable muscle tone, which does not allow the vocal cords to keep these parameters at a certain level.

Our analysis of the special literature shows that our home logopedics uses descriptive characteristics of voice impairments in children with various speech disorders, and practically lacks objective methods of voice indicators recording. Meanwhile, certain computer technologies have been worked out and are used in special pedagogy with diagnostic and rehabilitation-educational purposes [8; 14; 21; 22, etc.].

The computer-assisted system "Speech Viewer" based on graphic presentation of speech acoustic parameters is one of the results of such research activity. O. I. Kukushkina and T. K. Korolevskaya were among the first to explore the given information computer-based technology using it in their rehabilitation work with junior schoolchildren with auditory disorders [10; 11; 12, etc.].

At the contemporary stage of development of logopedics, the use of instrumental methods of investigation of voice characteristics in children with dysarthria would help to objectively record such indicators as melodic and dynamic components, presence of breathing and phonation coordination, and smooth speech acquisition. In this connection, we have undertaken a research of acoustic speech parameters in children of the junior school age with dysarthria using objective methods.

Study Organization

Our research was carried out at the base of the Moscow State Budgetary Education Institution "School No 158", structural subdivision No 3 (boarding school for children with severe speech disorders); Rehabilitation-Educational Center No 76; and Scientific-Practical Center of Children's Psychoneurology.

The sample included 50 children aged 7-10 years with the diagnostic conclusion "General Speech Underdevelopment (Third Level of speech development) caused by spastic-paretic form of dysarthria of moderate severity" (*hereinafter*: EG – experimental group). According to the medico-psycho-pedagogical commission, all schoolchildren of the EG had safe hearing, vision and intellectual development corresponding to the norm. The control group (*hereinafter*: CG) included 20 children of the same age without deviations in psycho-speech development.

The study of the voice acoustic characteristics was done with the help of the speech visualization tool *PRAAT* [25], which allows the researcher to undertake analysis, synthesis and procession of oral speech, visualize speech signals, and segment the flow of speech. We have studied the objective indicators of such acoustic parameters as fundamental tone frequency (FTF), voice intensity and maximum phonation time (MPT).

The study of the FTF was divided into two stages. At Stage 1, we recorded the FTF of various echoed constructions. The child repeated after the experimenter the following verbal material:

1) pronunciation of an isolated vowel sound;
2) echoed reproduction of syllables including sounds contrasted on the principle of being voiceless/voiced;
3) echoed pronunciation of words of various syllabic structure;
4) pronunciation of an articulatorily simple phrase;
5) pronunciation of automated series;
6) pronunciation of various types of intonation contours;
7) reproduction of a phrase with logical stress on the model.

At Stage 2, the experimenter asked the child to name words with different syllabic structure at their visual presentation. The computer program recorded the individual indicators of the FTF.

The voice intensity observation was focused on measuring the following:

1) the child's habitual voice intensity;
2) the minimum indicators of the child's voice intensity;
3) the maximum indicators of the child's voice intensity;
4) the dynamic range of the voice.

The fundamental tone frequency (in Hz) and the voice intensity (in dB) were evaluated via analysis of individual spectrograms.

The maximum phonation time was measured with the help of a stopwatch with the child pronouncing the long sound "a". Apart from the observation of the length of phonation exhalation, we paid attention to the presence of additional air intakes.

In all tests, we evaluated the following:

1) instruction understanding;
2) performance quality;
3) degree of independence during task performance.

Observation was conducted with each child individually.

Results of investigation of acoustic characteristics of voice in children with dysarthria and in typical children

1. Melodic range of the voice

Research outcomes of the FTF in pronunciation of a sound, syllables, words with different syllabic structure and phrases by the EG children showed that the lower boundary of the FTF was within the range of 144-200 Hz, the upper boundary – within 328-456 Hz. We have figured out that the average indicator of this parameter equaled to 165-372 Hz. The outcomes of observation of the melodic range of the voice in CG revealed that the lower boundary was within 199-296 Hz, the upper one – within 431-690 Hz, the average indicator value was 235-518 Hz, which coincided with the data of well-known investigations [24]. Figures 1 and 2 contain oscillograms of speech audio recordings of the EG and CG children while reproducing a four-syllable word "*pugovitsa*".

Figures 1 and 2 show that the child with dysarthria used a comparatively narrow range of frequencies (99.5-201.3 Hz) in comparison to the child without speech disorders (168.7-290.6 Hz). We can also state the insignificant inclusion of high frequencies of the range by schoolchildren with dysarthria. In addition, the pronunciation of the word by a child with dysarthria was characterized by the presence of an extra pause within the word and, as a consequence, lack of smoothness or fluency ("*pugovi…tsa*").

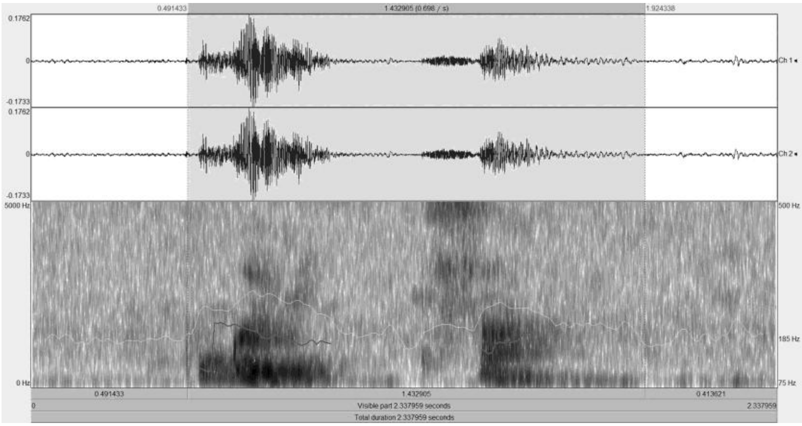

Figure 1. Oscillogram of pronunciation of the word “*pugovitsa*” by the EG children

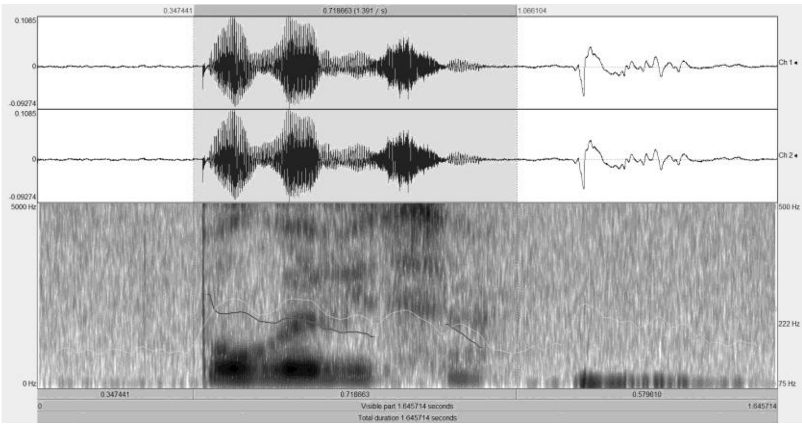

Figure 2. Oscillogram of pronunciation of the word “*pugovitsa*” by the CG children

The objective examples of the FTF parameters testify to the fact that the melodic range of the children with dysarthria was radically narrowed down compared to that of the junior schoolchildren without speech pathology. It was especially salient in reproduction of interrogative intonation, which is shown in Figures 3 and 4.

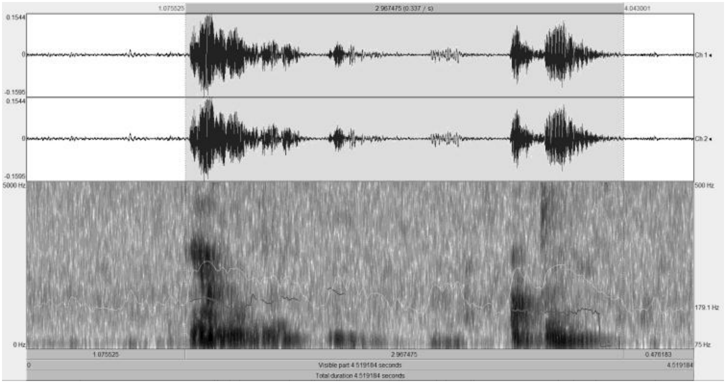

Figure 3. Oscillogram of pronunciation of a question by the EG children

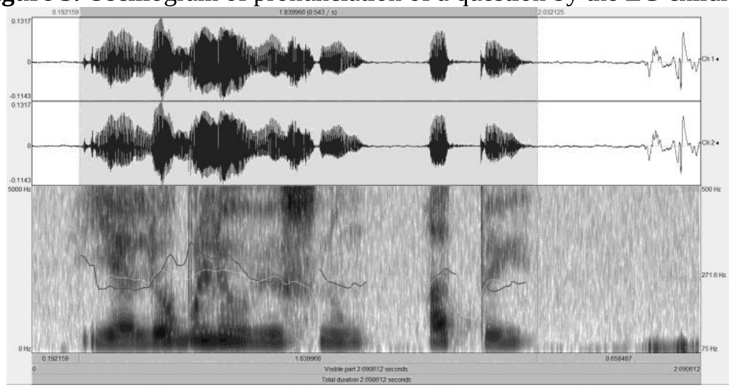

Figure 4. Oscillogram of pronunciation of a question by the CG children

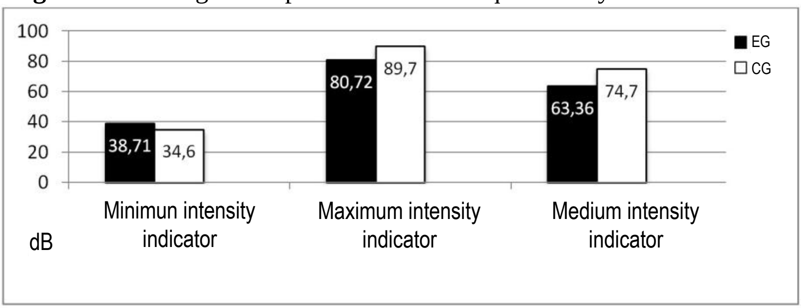

Figure 5. Average indicators of minimum, maximum and medium voice intensity

2. Voice intensity and dynamic range

The outcomes of objective research of the voice intensity in the EG have revealed that the minimum indicators fluctuated within the range of 31.2 through 46.6 dB; the maximum ones – within 68.6 and 88.3 dB. The range of average voice intensity indicator values was within 38.2 – 78.7 dB. In the CG, the lower boundary of voice intensity was 31.7- 38.1 dB, the upper boundary – within 86.9-92.7 dB, and the average indicator was within 70.3-79.1 dB. If we compare these outcomes with the results of the dynamic range analysis of the children without speech pathology, we can speak of reduced voice intensity indicators in the children with dysarthria, which is shown in Figure 5.

In voice modulations from quiet to loud, the majority of the EG children coped with the task; the dynamic range of their voices allowed them to change it within 39 dB, which was close to the norm. The observation results of this parameter in the children without speech disorders revealed the voice range not less than 50 dB both in cases of its increase and reduction. The transition from loud to quiet voice in the EG schoolchildren was impaired most dramatically: the difference between the lowest and the highest values was not more than 24 dB. To complete this task, the children needed repetition of the instruction and demonstration of the model; some children did not cope with the test.

3. Maximum phonation time

Observation of the maximum phonation time in the EG showed the indicator variability from 3 to 9 sec. In the CG, the length of phonation exhalation was 12-14 sec.

In the course of the experiment, fatigability of the children with dysarthria did not make it possible to carry out the whole test at one lesson. A proportion of the children could not understand the instruction at first presentation, they needed a second, and yet others a third one in order to understand it.

Discussion

Application of speech visualization tools on the basis of information technologies in the process of observation of oral speech of children with speech disorders allows the experimenters to obtain objective characteristics of breathing, voice parameters, articulation accuracy, etc.

The study of acoustic characteristics of the voice with the help of the speech visualization tool on the basis of information technologies *PRAAT* gave a chance to obtain objective data about the melodic and dynamic ranges, to reveal voice disorders in children with spastic-paretic form of dysarthria of moderate degree of severity in comparison with the norm.

It has been experimentally found that the frequency range of junior schoolchildren with dysarthria is narrowed down and reduced towards lower frequencies. Their dynamic range is also narrow; gradual reduction of voice intensity causes special problems. Significant reduction of the time indication value of maximum phonation has been experimentally revealed in such children in comparison to the norm. We believe that this is attributed to the immaturity of the abdominal breathing and prevalence of the pectoral breathing; shortened inhale and exhale phases. Weakness and instability of the breathing and articulation muscles tone and weakness of the diaphragm muscles are the main causes of a short phonation exhalation.

The objective data obtained in the course of our experiment about the impairments of the voice of junior schoolchildren with dysarthria testify to the complex organization of the pathological process involving not only the voice but also energetic basis of speech. They also demonstrate the necessity of purposive systematic work targeted at normalization of these indicators in the system of logopedic work with the children of the given category.

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