

ICPE 2018
International Conference on Psychology and Education

**DEVELOPMENT OF AN ALGORITHM FOR PHONOLOGICAL
DIAGNOSIS OF PRESCHOOL CHILDREN'S SPEECH**

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Abstract

The article presents a study of articulation and phonological speech disorders in preschool children according to standard classifications. The analysis of existing methods for examining the articulation and phonological aspect of speech in preschool children was carried out to substantiate the choice of methodology for creating a software algorithm. The process of development, automation and approbation of the automated complex for diagnosing the articulation and phonological aspect of preschool children's speech is described, as well as the results of the conducted surveys. The research involved 36 preschoolers with articulation and phonological speech disorders. The survey consisted of three parts corresponding with the three constituents of the articulation and phonological aspect of speech. During the diagnosis, we recorded the time spent examining the sound production, syllabic structure and phonemic processes. The analysis of the results has shown that the algorithm allows reducing the time to perform logopedic diagnosis significantly, which increases the effectiveness of speech therapy.

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Keywords: Articulation and phonological disorders, preschool education, school preparation, speech development, logopedic diagnosis, development of a logopedic algorithm.,

1. Introduction

A speech therapist deals with a wide spectrum of speech disorders. These disorders have various structure, thus requiring a thorough examination of the articulation and phonological aspects of speech, involving articulation of sounds, the syllabic structure of words and phonemic processes. (Spencer, 2015). Detection of violations in the articulation and phonological aspect of preschool children's speech is especially relevant today, since, have not been discovered in time, such violations lead to learning difficulties at school age.

Forming talking-readiness in children before schooling is one of the primary tasks of preschool institutions. Of specific importance is working on correct speech, so that it conforms to the language norms. Organizing a purposeful, systematic and effective work on the diagnosis and further development of speech skills in preschool children is possible only if we know what speech disorders are inherent in preschool children and what impact they have on the formation of full-fledged speech activity.

2. Problem Statement

All the constituents of the articulation and phonological aspect of speech are interconnected. Violation of phonemic hearing and perception prevent normal formation and development of such phonemic processes as phonemic perception, phonemic analysis and phonemic synthesis, without which it is impossible to acquire the syllabic structure of a word and literacy. (Wang & Li-Chih, 2017). All this indicates that the level of the articulation and phonological aspect of speech has a direct impact on a child's performance in primary school in Russian and reading classes, as well as in other subjects, since well-developed articulation and phonological aspect of speech is the first step on the way to becoming literate, acting as a scaffold for the whole process of learning to read and write.

In order to examine articulation, the syllabic structure of a word and phonology, a speech therapist must have the specially selected stimulus material (pictures, letters, syllables, words, phrases, texts) and correctly formulated instructions which are provided to the child before performing the tasks (Demina, 2014). Currently, such diagnostic materials are difficult to obtain, and they are insufficient and cumbersome in most cases.

To overcome these problems, diagnostic algorithms are being developed, recommended for use to reduce time costs and improve the effectiveness of the specialist. Within the framework of speech therapy, despite the importance and seriousness of the problem, algorithmization has been greatly underestimated.

3. Research Questions

All of the above necessitates development of an automated algorithm for diagnosing the articulation and phonological aspect of speech in preschool children at the stage of preschool education.

4. Purpose of the Study

Developing and testing the automated algorithm for diagnosing the articulation and phonological aspect of preschoolers' speech.

5. Research Methods

The research involved 36 preschoolers with articulation and phonological speech disorders, undergoing treatment at State budgetary institution of health care of the Kemerovo region "Kemerovo children's clinical psychoneurological sanatorium "Sparkle".

For the survey, we opted for T. B. Filicheva's technique, which underlies most of the existing methods of speech examination. In this technique, three blocks are identified for examining the articulation and phonological aspect of preschool children's speech: sound production, phonemic hearing and syllabic structure of the word. The technique describes methods applicable in a survey, and includes the model speech material that can be used for examination (Tasueva, 2016).

Prior to the survey, we have selected the necessary lexical (sounds, syllables, words and sentences) and visual material (pictures of objects). The survey consisted of three parts corresponding with the three constituents of the articulation and phonological aspect of speech. During the diagnosis, we recorded the time spent examining the sound production, syllabic structure and phonemic processes.

Computer software Statistica 10.0 was used for statistical analysis. We used the Student's t-test for independent samples to determine the differences in the mean values of time spent on the diagnosis of the articulation and phonological aspect of speech.

6. Findings

Descriptive statistics were used to visualize the time spent on each part of the survey, as well as the total time. The results are shown in Table 1.

Table 01. Descriptive statistics of the time to diagnose of the phonetic and phonological aspect of preschool children's speech

Variable	n	Average	min.	max.	Standard deviation
Time for part 1	36	48.7	45	53	2.8
Time for part 2	36	9.4	6	13	2.4
Time for part 3	36	10.8	8	13	1,9
Total time	36	68.9	62	79	4.6

It was found that the children pronounced 2 to 12 sounds incorrectly. Impaired syllabic structure was observed in 3 children, underdeveloped in 24 and unimpaired in 9. The phonological processes were impaired severely in 6, impaired in 24, underdeveloped in 3 and unimpaired in 3. Based on these figures, it is clear that all of the children demonstrate impairment of one or another component of the articulation and phonological aspect of speech. Diagnosing the speech production disorders took from 45 to 53 minutes. For syllabic structure – 6 to 13. Phonology – 8 to 13 minutes. The figures show that total time spent ranged from 62 to 72 minutes, with the standard deviation of 4.6 minutes, meaning that approximately the same amount of time was spent.

The survey revealed the following disadvantages of the current techniques of diagnosing the articulation and phonological aspect of the preschool children's speech:

- complex diagnosis is extremely time-consuming;

- veritable and thorough diagnosis requires a great amount of printed lexical and visual material;
- the techniques do not presuppose an algorithm for children with different speech impairments.
- the technique does not include the task necessary to assess the articulation and phonological aspect of speech in children with severe speech impairments.

The first stage of our study was developing a non-automated algorithm for differential diagnosis of speech disorders in children.

The development of said algorithm took into account the order and amount of the presented material at different disorders (according to clinical-pedagogical classification), as well as the sequence of examining the constituents of the articulation and phonological aspect of speech (Glotova, 2010; Zdor & Markova, 2016).

For a more thorough and accurate diagnosis, we decided to distinguish three “branches” in the algorithm according to basic disorders, described in clinical-pedagogical classification. Such differentiation was done via the first, introductory “branch” of the algorithm.

Since the order of tasks and their number depend on the supposed speech disorder the child is suffering from, we created the branch called “Initial Diagnosis”, which then transitions to the “branch” that corresponds with the supposed clinical-pedagogical diagnosis: dyslalia, dysarthria, rhinolalia, stuttering and alalia.

Automation became possible when we had finished developing the graphical algorithm of the articulation and phonological aspect of preschoolers’ speech, as well as the visual and lexical material, and the system of forming the speech therapy clinical report of the individual profile of articulation and phonology aspect of speech. The software implementation of the algorithm was carried out in C#. The software was created for Windows, the most common operating system in educational institutions.

Initially, the program asks the researcher to select the disorder from which the child suffers. It dictates the following sequence of tasks and their number. The way in which the individual profile is formed is also determined at this stage.

When the researcher has selected the disorder, the process of examining the sounds begins in the order predetermined by the algorithm. Diagnosing involves examining how the child pronounces the sound considered in following situations: isolated; open syllables; closed syllables; syllables with consonant clusters; words, where the sound is at the beginning, at the end and in the middle; phrases that include the sound. At each stage, the speech therapist reads out the instructions for the visual and lexical material.

To assess the task, there are buttons at the bottom of the task and instruction window, and an empty field where the therapist can leave his or her comment. When the "None" button is pressed, information about the child's inability to pronounce the sound under certain conditions is recorded into the individual profile. When the "Normal" button is pressed, information is recorded that the child is able to pronounce the test sound in the conditions under study. The "Impairment" button copies the information from the comment box.

After the algorithm had been automated, software testing was performed in order to find and correct errors in its operation. Testing of the algorithm took place at State budgetary institution of health care of the Kemerovo region "Kemerovo children's clinical psychoneurological sanatorium "Sparkle".

Descriptive statistics were used to visualize the time spent on each part of the diagnostics using the automated algorithm. The results are shown in Table 2.

Table 02. Descriptive statistics of the time to diagnose of the phonetic and phonological aspect of preschool children's speech using the automated diagnostics algorithm

Variable	N	Average	min.	max.	Standard deviation
Time for part 1	36	29.7	27	35	3.0
Time for part 2	36	3.8	3	5	0.8
Time for part 3	36	7.0	5	8	1.1
Total time	36	40.4	35	46	3.8

It was found that the children pronounced 4 to 14 sounds incorrectly. Severely impaired syllabic structure was observed in 3 children, impaired in 15, underdeveloped in 9, and relatively unimpaired in 9. The phonological processes were impaired severely in 30, underdeveloped in 6. Based on these figures, it is clear that all of the children demonstrate deviation in the formation of one or another component of the articulation and phonological aspect of speech. The pathologies were complex (all three components of the articulation and phonological aspect of speech) and partial (either syllabic, pronunciation or phonological processes were impaired). Diagnosing the speech production took from 27 to 35 minutes using the algorithm. For syllabic structure – 6 to 13. Phonology – 8 to 13 minutes. The figures show that total time spent ranged from 35 to 46 minutes, with the standard deviation of 3.8 minutes.

The differences in the mean values of time spent on the diagnosis of the articulation and phonological aspect of speech are presented in Table 3.

Table 03. A comparison diagnostic time indicators in the study groups

Variable	Control	Experimental	p
Time for part 1	48.4	29.7	0.01
Time for part 2	9.4	3.8	0.01
Time for part 3	10.8	7	0.01
Total time	68.9	40.4	0.01

The results presented in the table show that there is a significant decrease in all time indicators for the experimental group. The differences are significant enough to claim that using an automated diagnostic algorithm for preschoolers is more effective.

7. Conclusion

A graphic algorithm was developed and automated, visual and lexical material was structured, and an individual profile of the articulation and phonemic speech diagnostics of a preschooler was compiled in order to eliminate the deficiencies in the articulation and phonological speech diagnostic system. Comparative analysis of the results has shown that using the algorithm reduces significantly the length of logopedic diagnosis, which increases the efficiency of speech therapy.

Acknowledgments

The study was carried out with the financial support of the Kemerovo State University. Project "Development of a mobile phone application for speech correction in children with delayed speech development", 2018.

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