Computer-based Programs in Speech Therapy of Dyslalia and Dyslexia-Dysgraphia

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Abstract:
During the last years, the researchers and therapists in speech therapy have been more and more concerned with the elaboration and use of computer programs in the therapy of speech disorders. The main objective of this study was to evaluate the therapeutic effectiveness of computer-based programs for the Romanian language in speech therapy. Throughout the study, we will present the experimental research through assessing the effectiveness of computer programs in the speech therapy for speech disorders: dyslalia, dyslexia and dysgraphia. Methodologically, the use of the computer in the therapeutic phases was carried out with the help of some computer-based programs (Logomon, Dislex-Test etc.) that we elaborated and experimented with during several years of therapeutic activity. The sample used in our experiments was comprised of 120 subjects; two groups of 60 children with speech disorders were selected for both speech disorders: 30 where in the experimental ('computer-based') group and 30 where in the control ('classical method') group. The study verified whether the results, obtained by the subjects within the experimental group, improved significantly after using the computer-based program, compared to the subjects within the control group, who did not use this program but got a classical therapy. The hypotheses were confirmed for the speech disorders included in this research. The conclusions of the study confirm the advantages of using computer-based programs within speech therapy by correcting these disorders, as well as the positive influence these programs have on the development of children's personality.

Keywords: computer-based program, speech therapy, children, dyslalia, dyslexia, dysgraphia.

1. Introduction

During the last decade, the technological progresses influenced speech therapy in two major ways: firstly, the use of computers and other communication tools facilitated communication among persons with speech disorders; secondly, computers were used in speech therapy, contributing to the acquisition of written and verbal language with help of various computer-based programs and software [10]. The use of computers contributes to the learning process by increasing the attention focus, developing the use of language and social skills. It is well-known that the use of computers increases the subjects' curiosity and their interest in the activities involved in the therapy, as it stimulates strong feelings and affective states. Through its nature, an image is a synthesis of affectation and knowledge. At the same time, we should not neglect a better knowledge of speech and personality particularities of these children, the age particularities and the level of mental processes and of the development of child language. We should also take into account the character of representations, the attention to details, the generalization and conceptualization possibilities, their capacity to receive and interpret auditory and visual stimuli [9], in order to ensure the individualization and effectiveness of the therapeutic program.

The specialists [6] came to the conclusion that the use of software in speech therapy:

- contributes to the diagnosis of speech disorders,
- produces audiovisual feedback during the treatment,

- monitors and assesses the therapeutic progress,
- provides various types of practical exercises for children with speech disorders.

2. Computer-based aids in the context of special psycho-pedagogy

In speech therapy, the use of instructive computer-based programs increases the subjects' curiosity and their interest in therapy and it stimulates strong feelings and affective states [2]. The current priorities in speech therapy consist of developing computer-based systems capable to personalize therapeutic guides according to the child's evolution and to assess their progress. The audiovisual techniques should be used with caution, finding each time their justification within a clearly-stated psycho-pedagogical approach [11]. We underline the fact that audiovisual techniques, whose virtues have been stated by several educators, may lead to a sort of image verbalisation, when they only favour associations with no connection to authentic activities. Therefore, in order to prevent shortcomings in improper use of audiovisual techniques, the therapist, through his knowledge and inventiveness, manages to acquire an important help in his therapeutic activity [4].

The Romanian speech therapy registered research and experiments contributing to an improvement in the therapeutic progress of speech disorders. Thus, we can exemplify:

1. Speech re-education in the stuttering therapy by means of the "delay auditory feedback" (DAF) was experimented after the publication of the works of Lee [5]. The delay of the auditory feedback calls for the use of some electronic devices that allow the modification of the delay for the perception degree of one's own speech, according to the requirements of each particular case; therefore, stuttering patients can hear their own speech with a delayed feedback. Starting from such results, and after various experiments, the electronic device called "ecophone" was elaborated and improved in Romania [9].

2. The use of computer-based programs does not eliminate the therapist, but they become effective partners in reaching the therapeutic objectives; they represent an effective support in speech therapy exercises, as well as a particular action method upon the psyche of the child [3].

3. Starting from the classical therapeutic exercises, we note the elaboration of Logoped 1.0 [9] which includes methods to eliminate breathing dysfunctions, spasms and intonation monotony.

4. There are also computer-based applications used to correct dyslexia-dysgraphia which aim to reduce/eliminate the optical-spatial confusions between the graphemes, and, implicitly, to improve the lexicographic performances of the subjects.

5. The CEEX project [8], *"System for the personalized therapy of linguistic disorders TERAPERS",* is the result of the collaborative work of the "Al. I. Cuza" University at Iaşi, "Ştefan cel Mare" University at Suceava, and "Gh. Asachi" University at Iaşi; its purpose was to elaborate and implement an intelligent therapy system for speech disorders, specific to the Romanian language (computer-based speech therapy), as an additional, personalized and subject-centred speech therapy method. The software includes a computer-based systematization of the speech therapy, contributing to the elaboration of comparative analyses among various users of the program and opening new perspectives for international research, by processing an impressive amount of data within the therapy of dyslalia for the Romanian language.

3. Experimental Design

In order to evaluate the therapeutic effectiveness of computer-based programs in speech therapy, we carried out an experimental research in order to assess the effectiveness of computer programs in the speech therapy for various speech disorders: dyslalia, dyslexia-dysgraphia.

The objective of research was to compare the results of the complex language evaluation for the group who used computer-based programs with the results obtained by the group who used classical therapeutic methods.

Methodology. From the methodological point of view, the computer-based programs—that we elaborated and we experimented with during several years of therapeutic activity—replaced the tables and drawings used in the classical therapy. In establishing the speech therapy diagnosis, we

used examination tests characteristic to the language disorder and aiming at the essential aspects of the respective disorder. In order to increase the therapy efficiency, we carried out a complex evaluation of dyslalia, consisting of: a Test for establishing the speech psychological age (adaptation of the model of A. Descoudres), a Reflected speech test (the child repeats after the speech therapist 20 words in which the defective sounds are placed at the beginning, in the middle and at the end of the words), and an Independent Speech Test (the child is shown 20 images that (s)he is supposed to word independently, without the help of the speech therapist. The words contain the defective sounds at the beginning, in the middle and at the end of the words) [12]. Also, in order to increase the therapeutic efficiency of dyslexia and dysgraphia, we applied: the Test for establishing the language psychological age, the Test for evaluating the reading/writing ability [12]. The children included in this study were selected according to their age, the type of their speech disorder, its degree, as well as the degree of intellectual development.

Research sample. For the research, for each speech disorder (dyslalia, dyslexia-dysgraphia) we selected each 60 children: 30 subjects for the experimental ('computer-based' therapy) group and 30 subjects for the control (classical therapy) group. The subjects selected are 8-9 years old and they have a normal level of intelligence (Raven test was used). We took into account the homogeneity criterion in order to select the children for the four groups; also, the average scores were equivalent for the complex evaluation tests for each speech disorder, demonstrated by applying in each case the Anova One Way and Bonferroni tests upon the scores.

4. Results and discussions

After the logopedic evaluation of the subjects investigated, we started the statistic processing of the data obtained and the analysis of the results of the tests administered to both groups for each speech disorder (dyslalia, dyslexia-dysgraphia) during one year of speech therapy. This analysis regarded both the speech therapy effectiveness overall, and the influence of strategies used to stimulate and develop the language, based on the use of computer-assisted Logomon software.

1. Analysis of the results using the computer-based program Logomon for dyslalia.

The research project aimed at elaborating and implementing a computer-based intelligent therapy system for pronunciation disorders (dyslalia), specific to the Romanian language, as an additional, personalized and subject-centred speech therapy [3]. The interdisciplinary collaboration in the elaboration and the implementation of this system was materialised in the electronic transposition of the speech therapy methods (speech therapy observation charts, speech therapy records, medical histories, questionnaires for patients, lists of sounds, syllables, words, sentences).

The computer-based system proposed and used in the experiments had two main components:

a) The calculation system of the speech therapist, which includes:

- a 3D virtual model of the phono-articulatory system;
- an audio component monitoring children's evolution, with exemplifications;
- an expert system which produces inferences by taking into account the audio data evolution, provided by the monitoring system.

b) The mobile device, used by the speech therapist, including home practice.

The PDA (Personal Digital Assistant) S for this application comprises 3 components:

1. audio component (recording, processing, feed-back)
2. graphic component (appropriate interface)
3. calculation facilities necessary for the evaluation procedures and for the communication with the PC of the speech therapist.

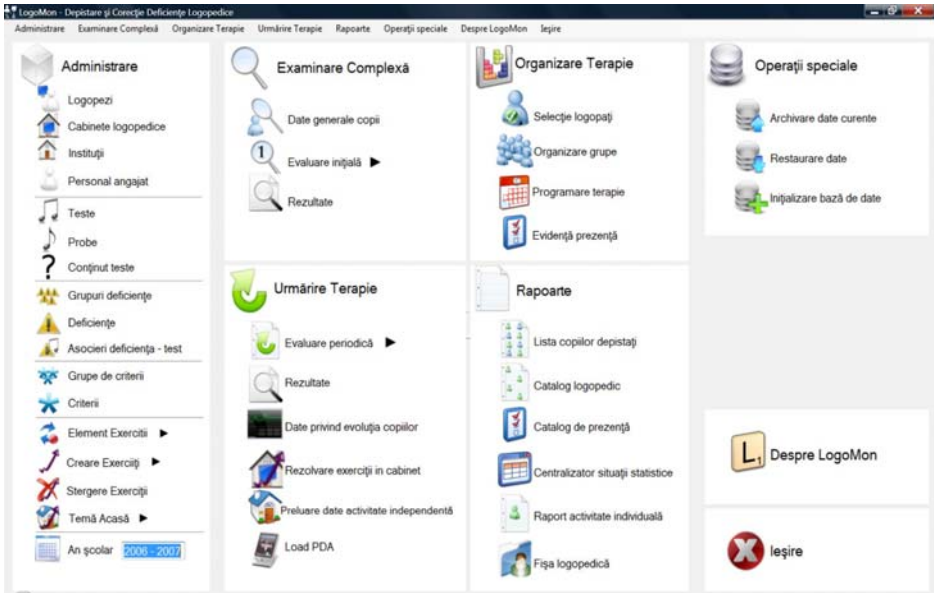

Figure 1. Logomon – Program menu

The examination part of the software includes all types of information necessary to understand each case [9]:

1. Personal data (last name, first name, date of birth, address, telephone etc.)
2. The medical history is recorded following the discussions with one of the parents (preferably with the mother) and consulting the child medical record. At this stage, the hereditary diseases, malformations, the information on the pregnancy (Rh compatibility), the birth (APGAR score – the very first test given to newborns - Activity, Pulse, Grimace, Appearance, and Respiration), infectious diseases that left traces, affectivity development, psycho-physical progress, trauma and accidents suffered, apparition and evolution of language (when and how did the child begin to talk, the first words, the first sentences), etc. should all be mentioned.

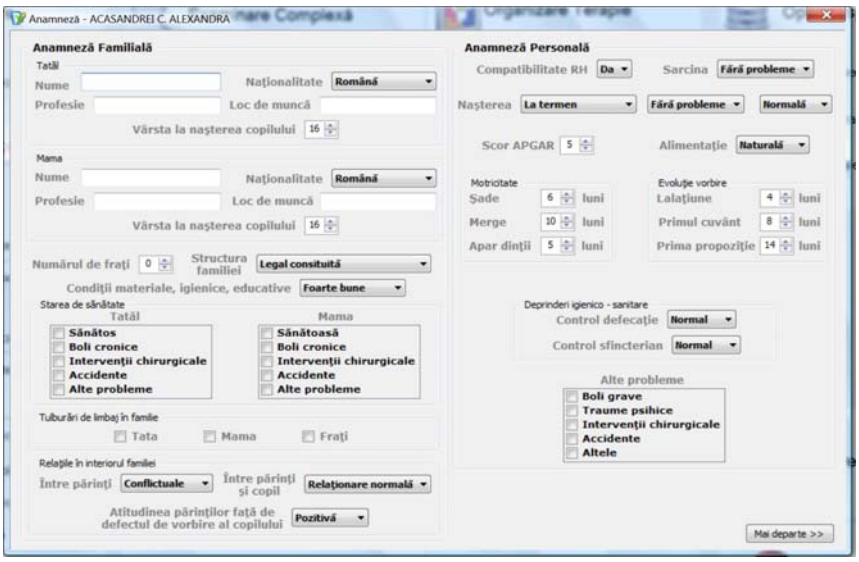

Figure 2. Logomon Program – medical history (fragment)

3. The initial evaluation may include all sounds, but it is compulsory to evaluate the sounds of the letters s - voiceless alveolar fricative [s], ş - voiceless postalveolar fricative [ʃ], ţ - voiceless alveolar affricate [t͡s], r - apico-alveolar [r], based upon a logic algorithm of the tests.

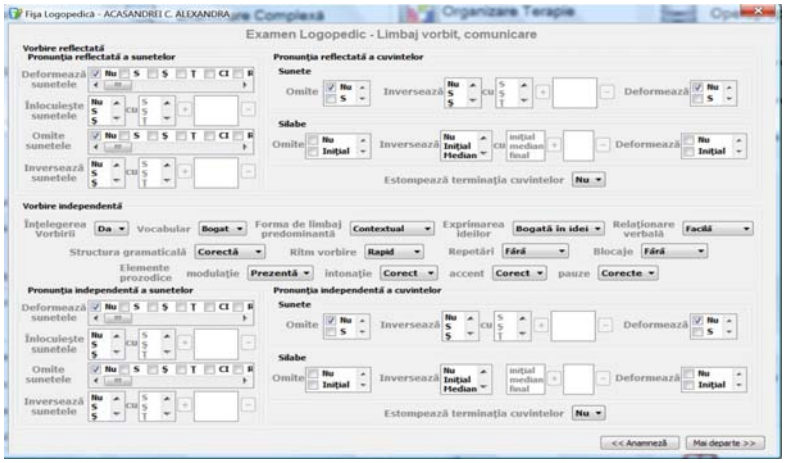

Figure 3. Speech therapy examination –Speech, communication (fragment)

The complex speech therapy evaluation aims at the reflected and independent pronunciation of the sounds, both independently, and within syllables, words and sentences. It records the distortions, the replacements, the inversions, the omissions of sounds, as well as the prosodic elements (modulation, intonation, accent, speech pauses). Moreover, the speech therapy examination monitors the functional integrity of the phono-articulatory apparatus (occlusion, dentition, tongue, lips, soft palate, and larynx), aspects of the facial, lingual, labial, velar motricity, body scheme, and breathing apparatus. The electronic speech therapy record filled in extensively gives an ample image of the speech disorders of each child.

4. The speech therapy examination comprises all the important evaluation fields:

a) Reflected and independent pronunciation.

The elaboration and administration of an inventory of tests for examining the independent and reflected speech in the evaluation of each sound constituted important elements in realising the files within the Logomon program.

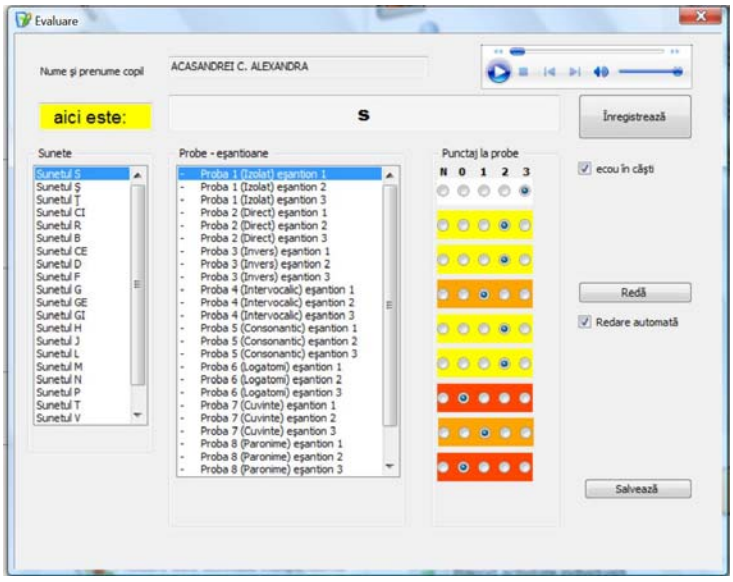

Figure 4. Reflected and independent speech evaluation –Logomon program

In the evaluation of the independent and the reflected speech, 9 tests were created for the speech pronunciation evaluation. The tests were structured as follows:

- isolated sound pronunciation (3 times);
- sound pronunciation test within direct and reverted syllables;
- sound pronunciation test within words in which the sound is placed in initial, median, and final position;
- sound pronunciation within paronyms;
- sound pronunciation within sentences.

b) Examination of the phono-articulator system.
c) Examination of the body structure.
d) Examination of the breathing system.
e) Examination of the personality.

5. The computer, supervised by the speech therapist, sets a presumptive and a final diagnosis (but not the differential diagnosis).

6. The computer monitors each child's pronunciation evolution, by recording and comparing the data from the beginning to the end of the therapy. The length of the treatment depends on the evolution of each child during the impostation, consolidation and automation stages of the sound defectively pronounced.

7. The speech therapist makes a series of therapeutic suggestions which represent a preparation phase before the therapeutic intervention itself.

8. The program for the general and the specific therapy includes various and rich programs which maintain the children's motivation and interest in the therapy [4].

9. The 3D system is a useful material which constitutes the visual support for understanding the position of the various components of the phono-articulatory system while pronouncing different altered sounds. The possibility of a visual interaction with the correct pronunciation model proposed by the 3D graphical model contributes to a faster impostation of the sound defectively pronounced. Compared to the classical speech therapy, sound impostation is significantly improved, since the child is able to understand the positioning of the phono-articulatory apparatus during sound emission. The 3D model presented interactively determines an easier intuition of the correct verbal model; in the classical therapy, the child is required to imitate the movements presented by the speech therapist. In the new circumstances, the child is able to visualise the correct verbal model, acquiring thus the correct positioning of the tongue and the teeth, as well as the direction of the air flow during sound emission, etc.

These programs aim at a computer-based systematization of the speech therapists' activity, which has the advantage of eliminating the traditional way of evaluating and making speech therapy records ("paper and pencil"). It also opens new perspectives for international research, through processing an impressive amount of data within the dyslalia therapy for the Romanian language. The Logomon program also includes the homework management system (installed on the child's PC or PDA), the management system of the therapeutic tasks accomplished in the cabinet, and an expert system which has the role of making decisions regarding the best therapeutic activities that each child should apply (number of sessions, contents of therapeutic exercises etc.) [8]. Nevertheless, we underline the fact that the main decision factor is the speech therapist.

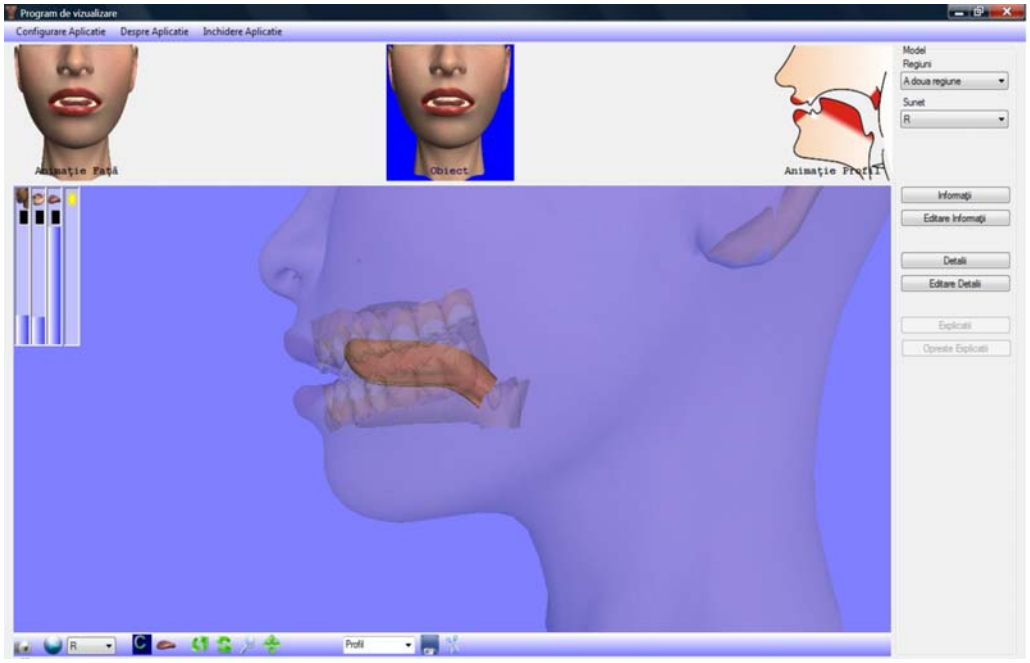

Figure 5. 3D Model – the position of the phono-articulatory organs during the emission of the sound [r]

In the classical therapy of dyslalia, a series of general methods and procedures are applied at the beginning, according to the severity of the disorder. These aim at preparing and facilitating the application of the specific speech therapy methods and procedures, particularised to each case and according to the nature of dyslalia. In the category of general methods and procedures are comprised: gymnastics and myo-gymnastics of the body and the organs participating in pronunciation; breathing training and training of the balance between inspiration and expiration; phonematic hearing training; personality training; eliminating negativism towards speech and some behavioural disorders.

Specific therapy is carried out by taking the following steps: sound emission and impostation, consolidation and automation. In the stage of sound emission and impostation, the following methods are used: demonstration and practicing the sound articulation in front of the logopedic mirror, deriving the new sound from the correctly emitted sounds that are similar by the motor-kinestesic execution and phonetic form. In the stage of sound consolidation, various exercises are carried out, and in the most diversified articulatory combinations: direct, indirect, intermediary syllables, consonantal groups, monosyllabic, disyllabic, and polysyllabic words. In these exercises, the defective sound is placed at the beginning, in the middle and at the end of the word. In the sound automation stage, the corrected sound is used in building sentences, simple at the beginning, and then more and more complex (developed sentences, stories, riddles, proverbs). This stage aims at the following exercises: creating simple sentences in which the defective sound is present at the beginning, in the middle and at the end of the words used; sentences with constant beginning, end, or in which the defective sound is highly present; exercises for memorising poems, riddles, proverbs, storytelling starting from images, movies, drawing boards; essays on given themes, or free essays.

In carrying out the Romanian computer-based system (Logomon), for the evaluation, diagnosis and speech therapy of dyslalic forms, the classical therapy of dyslalia was algorithmically transposed for each consonant in the Romanian language, translating into pseudocode and logograms each stage of the speech therapy as well as the specific sub-stages. The pseudocode is a series of logograms, connected to each other by decision trees, which allowed for a greater flexibility and customisation of the speech therapy.

Hypothesis 1

The results obtained by the dyslalic children (with pronunciation disorders) within the experimental group are significantly improved following the computer-based therapeutic program Logomon, in comparison to children in the control group, who did not benefit from the program but of a 'classical' therapy.

Table 1. Mean, mean standard deviations and mean standard errors for the independent speech variable in dyslalic children (control group and experimental group)

Group Statistics

	GRUP	N	Mean	Std. Deviation	Std. Error Mean
independent speech test	control	30	16.6333	1.12903	.20613
	experimental	30	18.0667	.98027	.17897

Table 2. Independent Samples Test for the independent speech variable in the two groups of dyslalic children

Independent Samples Test

		Levene's Test Equality of Varian		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tail	Mean Differenc	Std. Errc Differenc	Lower	Upper
independent speech test	Equal variances assumed	1.236	.271	-5.25	58	.000	-1.433	.2729	-1.9797	-.8868
	Equal variances not assumed			-5.25	56.87	.000	-1.433	.2729	-1.9800	-.8866

The difference between the two means is statistically significant t(58) = -5,25; p < 0,01; therefore, the performance in the independent sample test for the children from the group that used the computer in the automation stage is significantly better than in the case of patients who followed the classical treatment of dyslalia. The hypothesis was confirmed. The difference between the two groups is given in Figures 6:

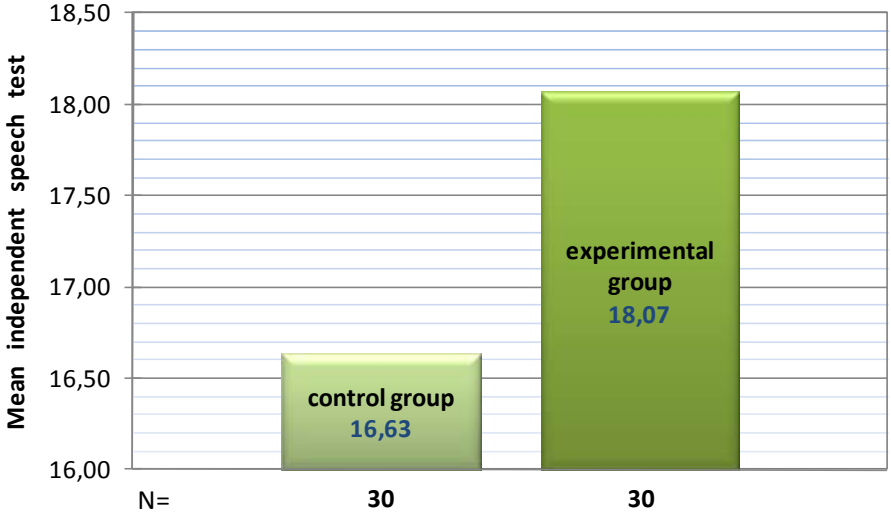

Figure 6. The difference between the two dyslalic children groups

The qualitative analysis of the data demonstrates the main factors determining the speech therapy effectiveness of the computer-based program: the great interest shown by the subjects, the

fact that children pay attention to the computer, makes the task of the speech therapist much easier; (s)he no longer has to be looking for papers or pencils, but (s)he only has to move the mouse.

The results of the dyslalia treatment are the following:

a) an increase in the effectiveness of therapeutic interventions within the language disorders treatment as a result of diversifying the therapy by using computer-based programs;

b) the quantification of the progresses;

c) the precise error discrimination and identification.

The Logomon program turned out to be a real help in the therapeutic activity, by providing various exercises that children can do both in the test cabinet and at home. The program is also very useful with respect to the organization of the therapeutic process, as it helps the therapist in selecting and organizing the therapy, the schedule and keeping record of children's presence at therapeutic sessions. The Logomon program allows printing various documents that the speech therapist may need (list of children with disorders, statistical data centralizer, individual activity reports etc.). We also find very useful the exercises which include a concrete support (images), as we know very well that pre-school children work best with concrete images [4]. The programs can also file the current data, update useful data and initialize new databases.

2. Analysis of the results using the computer-based program Dislex-Test for dyslexia-dysgraphia

We believe that some of the objectives of the dyslexia-dysgraphia therapy could be more effective if the treatment also included a computer [2]. The use of the computer in the dyslexia-dysgraphia therapy may be conceived on two coordinates: in order to produce electronic "work sheets" with all the advantages (especially for visual perception) involved in this manner of presenting the letter stimuli: luminosity, contrast, colours, movement etc., and also as it allows a great volume of lexicographic material to be used during each therapy session. We all know how important it is to form and develop the orientation and spatial-temporal structuring capacity for children to read and write, especially children with intellectual problems. Observing that practicing the differences between the graphemes that are similar from an optical point of view has positive effects on the lexicographic act in general, we believe that such a computer-based program would be useful in treating the dyslexia-dysgraphia [1]. Therefore, the elaboration and application of the Dislex-Test program aimed primarily at dissociating among the similar graphemes from an optical point of view m-n; u-n; p-b; b-d; independently, in words, and in sentences. The working hypothesis stated that by training the pupils in making these dissociations, the visual and spatial confusions among graphemes could be reduced/eliminated and, implicitely, the patients' lexico-graphic performances could be improved. The program comprises four modules with several sets of exercises for differentiating the letters: "m"-"n"; "u"-"n"; "p"-"b"; "b"-"d", that can be accessed directly from the menu. The text of the program was displayed as clearly as possible on the screen, with a visible and coloured font, favourable for the visual perception, essential in eliminating the confusions among the various letters in writing and reading. For each working sequence, the task is displayed in the right-hand side of the screen. After using the program several times, the pupils learned how to access it, how to enter the menu and solve various exercises. Obtaining immediate results, the children felt better about themselves, which is crucial for the future learning process. Even though the teacher's intervention cannot be replaced by a computer, it does help to improve children's reading and writing capacity. Therefore, the patient is first required to choose the word containing the letter aimed at, considering that in the sentence there are no other words containing letters that could determine optical confusions; then, the sentences get more difficult, containing both types of letters that could be confused (for example, in the first case, the pupil is asked to find in the given sentences the words containing the letter "m"; in this case, the sentences do not contain words with the letter "n". Then, the pupil is asked to identify the words containing the letter "m" in sentences that include both words composed of the letters "m" and "n"). The position of the affected letters differs within the word: at the beginning, in the middle, at the end, in order to familiarise the patient with all the possible situations. The patient is trained to dissociate between

the problematic letters presented first within letters diagrams, then in mono- and polysyllabic words, and finally within sentences. The dissociation at the level of letters was first complicated by the different writing styles (normal, bold, italic), aiming thus at preventing rigidity and stereotypy, and determining the child to adapt to various situations. Moreover, the structure of the letters diagrams was diversified, in order to avoid the memorisation of the correct answer. For each model of the program, the items must be solved in the order in which they are given, determining the child to go through all the stages in solving the task. The passage from one sequence to another of each model is possible only if the previous sequence is correctly solved. The therapeutic intervention consisted of solving the exercises *to make the difference among the optical and spatial similar graphemes*, for 15 minutes per therapy session, twice a week for a semester: the pupils within the *control group* did their exercises on work sheets, and the pupils within *the experimental group* did the same exercises assisted by a computer. The exercises on work sheets had the same design and structure as those on the computer, but, unlike the computer-based therapy, in the classical therapy the feedback is done at the end of every session, after correcting the papers and encouraging the pupils who improved their performances, or drawing attention to their mistakes.

Hypothesis 2

The results obtained by children suffering from dyslexia-dysgraphia (reading-writing disorders) within the experimental group are significantly improved after following the computer-based therapeutic program, in comparison to children within the control group, who did not benefit from the program but had been treated with a classical method therapy.

Table 3. Mean, standard deviation and mean standard errors for the sentences writing/reading variable in the children from the control group and the experimental group

Group Statistics

	GRUP	N	Mean	Std. Deviation	Std. Error Mean
writing-reading sentences test	control	30	12.3033	1.19237	.24729
	experimental	30	16.7107	.96259	.15732

Table 4. Independent Samples Test for sentences writing/reading variables in the children from the control group and the experimental group

Independent Samples Test

		Levene's Test Equality of Varian		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tail	Mean Differenc	Std. Erro Differenc	Lower	Upper
Writing-reading sentences test	Equal variances assumed	1.158	.262	-6.29	53	.000	-1.392	.2519	-1.782	-.8759
	Equal variances not assumed			-6.29	53.94	.000	-1.392	.2519	-1.782	-.8759

The difference between the two means is statistically significant $t(53) = -6,29$; $p < 0,01$; therefore, the performance in sentence writing/reading for the children from the group that used the computer is significantly better than in the case of patients who followed the classical treatment. The hypothesis was confirmed. The difference between the two groups is given in Figures 7:

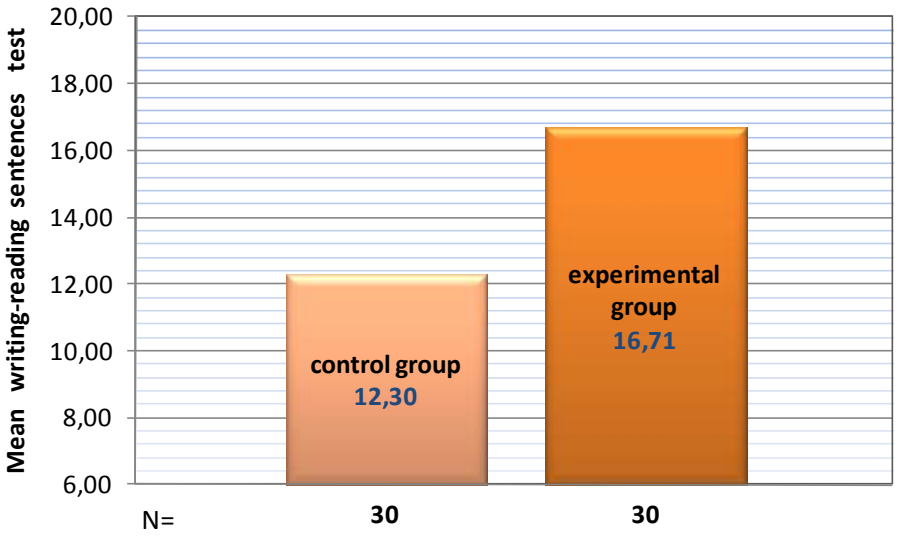

Figure 7. The difference between the two groups of children with dyslexia-dysgraphia

Generally, we notice an increase in the performance for each pupil within the experimental group, which means that, statistically, each pupil managed to learn better than the pupils who followed the classical therapy. The results obtained in the initial and in the final evaluation demonstrate the performance of the pupils within the experimental group, regarding the number of correct answers. This is due to the fact that children got used to the words and that they began to understand the proper meaning of words presented during the experimental program, as well as to the fact that this program stimulated the pupils' motivation to accomplish the tasks given; thus, both the number of correct answers, and the execution time improved.

The qualitative interpretations of the tests show that they may constitute the basis for speech development programs, teaching frontal or individual, at primary school level. The teaching structure should include a comprehensive initial evaluation of the semantic vocabulary for each pupil when starting school, then teaching should continue by introducing the child to a specific verbal stimulation program and it should end with a final evaluation of the results [7]. The corrective methods for dyslexo-dysgraphia which include computer-assisted instruction software stimulate the children's interest and motivation in the activity, and also in cooperation in order to accomplish all the tasks given.

The improvement of the reading-writing capacity could be explained by the *advantages* of the program:

– it allows the individualization of tasks;
– the progressive increase in the difficulty of the exercises;
– the access to the next exercise is conditioned by the correct solving of the current one;
– the use of various editing styles for letters requires the pupils' adaptive skills;
– there is an immediate feedback, and, for every correct answer, there are visual rewards, that is bright coloured images (pictures of flowers), increasing thus the pupils' self-esteem;
– it develops the eye-hand coordination and the precision of movements;
– it stimulates the focus;
– it develops the capacity of analysis and synthesis;
– it stimulates the visual perception and the observation capacity;
– once pupils get familiarized with the tasks within the program, there are very few cases when the speech therapist has to train them in order to solve the exercises;
– it allows the cooperation and competition among pupils, with strong motivational values.

5. Conclusion

All the statistically processed results underline the significant progresses made by the experimental groups after applying computer-based programs, in comparison to the control groups, which demonstrates the fact that the therapeutic programs elaborated and applied influenced positively the proper pronunciation and reading-writing acquisition.

The computer-based therapeutic methods stimulated the pupils' interest and motivation in their activity and in accomplishing all the tasks given.

The overall results show that the methods using a computer-based program determine a faster progress in correcting the speech disorders within speech therapy.

The use of such computer-based methods during various phases of the speech therapy determines a new psychological and pedagogical situation by creating a special learning environment, and by facilitating a new, superior method for correcting and developing speech.

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