Computer-based screening test of Dyslexic High School Students in Greece

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ABSTRACT

The diagnosis of dyslexia is made by mainly taking into account the reading skills of the child. Screening for dyslexia, on the other hand, is an initial useful indicator before diagnosis. Recently, various types of software have been created in order to screen Dyslexia. The main advantage of this kind of software is the creation of a pleasant environment for the user, while they achieve more accurate results in less time, in contrast to the classic clinical trials. The aim of this study was to create, for the first time an online software for screening dyslexia in Greek High School Students. For that purpose, the software «DysCreTe» was created, which consists of nine tests that assess children in reading, spelling, arithmetic and cognitive skills. Our research design consists of random sampling and application to both typically developed and dyslectic children in order to analyze the results and investigate if children with dyslexia will show significant differences both in the mean scores and also in the time of completion of all tests. According to our results, students with dyslexia lagged significantly compared to the typically developed ones. Consequently, the online software «DysCreTe» is a useful tool to screen dyslexia in Greek High School Students.

Keywords: dyslexia, screening tests, online software, cognitive skills

INTRODUCTION

The term special learning disabilities describe inherent disorders, which cause difficulties to children in their daily school life. Specifically, disorders that can affect only one cognitive or functional brain domain or more (Willburger et al., 2008). In other words, they are functional or cognitive deficits that occur in a person from the moment of its birth and difficult him in his daily life at school (Callinan et al., 2015). The essential difference between special learning disabilities and generalized learning disabilities is that generalized learning disabilities may be caused due to external factors, such as family environment or if the school does not assist students during the learning process (Mavrommati, 2004). In the above cases, it has been observed that students have low performance, due to secondary factors, which should not be confused with the cases of children with special learning disabilities (Mavrommati & Mile, 2002).

Special learning disabilities include dyslexia, dysorthography, dysgraphia, dyscalculia and more (Rourke, 1997). Developmental dyslexia affects 5% to 15% of the student population, depending on how strict the definition of dyslexia is (Martino et al., 2001). In Greece, it is estimated that the percentage of students with dyslexia is about 5.52% (Vlachos et al., 2013).

Previous Research

Screening for Dyslexia mainly assesses the reading skills of the child, which should be significantly lower than expected for his age group to place the children in question into the high-risk group. One of the biggest difficulties faced by dyslexics is the ability to match effectively written texts (graphs) with sounds (phonemes). The main reason is the attenuated audio processing, which ultimately affects phonological processing (Zygouris et al. 2017).

According to Singleton (2001), computer-based dyslexia screening provides a simple, direct and objective way for teachers to assess children who have learning difficulties and screen existing or potential learning problems obtain basic diagnostic information and measure children's progress generally. Moreover, they can evaluate individual responses to support children with special learning disabilities and obtain information that will be useful to psychologists at a later time.

On the one hand, the advantages of computer-based screening are the objective and standard presentation of results as well as the fastest management of participants. Furthermore, greater accuracy of evaluation, time and cost savings are achieved as less training of users is required. Finally, the results are immediately available and the process is enjoyable for children and confidential for adults.

On the other hand, the critical issues and risks involved in computer-based screening are that boys have an advantage over girls in computer-based tests and creating computer tests requires a significant investment in time and money. Certainly, computer screening is limited in some aspects of evaluation and there are risks, as technology may not cover certain areas of neuropsychology (Singleton, 2001).

Consequently, computer-based screening cannot replace the diagnosis by a professional expert but it could be a useful tool, as long as it is carried out with the understanding that it can only give an indication of possible dyslexic difficulties. Furthermore, the interdisciplinary team that deals with the differential diagnosis of a child has the training to create the appropriate intervention program, something that cannot be done by a computer (Watson & Willows, 1995).

Dyslexia screening through software

Dyslexia screening could take place either through software or through Internet (online) applications. Some of the most popular computer-based assessment programs for screening dyslexia are mentioned in this section.

Lucid CoPS (Cognitive Profiling System) has been created in the United Kingdom to identify learning difficulties and to screen dyslexia timely. Its results assist personalized intervention programs to be developed that will help children in their everyday lives.

Lucid Rapid Dyslexia Screening performs a quick screening of dyslexia in children, aged between 4 and 15 years old, in just 15 minutes. The program provides each child with three delightful tests and each individual test has been carefully standardized, validated, and calibrated to maximize accuracy. It is therefore a quick process to place the children in question into the high-risk group.

CoPS Baseline is used to screen dyslexia in children between 4 and 5 years old. It assesses the abilities and level of development of children at school. CoPS Baseline gives the teacher a snapshot and a profile of each newcomer student. This profile will determine each student's level and identify its strengths and weaknesses. Tests assess math and communication skills. An additional test (involving personal and social skills) consists of a simple on-screen questionnaire completed by the teacher. The program generates six different types of reports automatically for both teachers and parents.

LASS Secondary uses standard templates for students between 11 and 15 old and includes a range of fun challenges and tests in the form of games that measure logic and cognitive skills, including memory and phonology. Interpreting the results of the program is simple using standard graphic profiles that make it easy to identify poorly performed students. It can also quickly identify dyslexic difficulties, such as phonological awareness or memory problems. The results are detailed and can be easily analyzed. This program can also be used on a regular basis (e.g. every quarter) to monitor progress in reading and spelling or to test phonological awareness. All this information can be used to design customized training programs and to decide whether or not to request a formal evaluation by a psychologist.

Lass Junior is a scientifically proven multifunctional assessment system for all students. It uses standard templates for students between 8 and 11 years old. Lass Junior was designed using the successful design of Lass Secondary. The eight enjoyable evaluation modules employ a unique and sophisticated algorithm developed by Lucid, which ensures that estimates are as short as possible without losing their accuracy. Modules assess the logic and cognitive skills, including memory and phonology. The interpretation of Lass Junior results is simple and the use of standard graphic profiles makes it easy to identify students who perform poorly in general or in relation to their intellectual potential. The items included cover a full range of competencies, both for students below or above average. It can quickly identify cognitive problems in phonology, memory, and a dyslexic profile. Detailed results are also easily accessible for analysis. Evaluation can be done at regular intervals (e.g. every quarter) to monitor progress in reading and spelling, or to monitor the development of phonemes.

Dyslexia screening through Internet software

Over the last 15 years, Internet technology has provided opportunities to develop continuous assessment software that produce a profile of the weaknesses and abilities of the children in question. The use of computers for concerning screening of learning disabilities is now established in UK schools, with a number of different software programs available, (Landerl et al., 2004; Desoete et al., 2009). However, no corresponding internet software has been created in Greece.

Zygouris and other authors (2015) created "askisi", for screening special learning disabilities in children aged from eight to twelve years old. The software includes 10 tests that assess children in reading, spelling, arithmetic, and cognitive skills.

In all tests, the online application "askisi" counts the time needed for the examinee to complete them, except for the fifth test, where the working memory is tested. In addition, "askisi" has two forms that are addressed according to the age group of the children.

According to the results obtained from the application of the software, children with special learning disabilities were observed to have fewer correct answers in all the tests and need more time to complete them than their typical developed classmates. Therefore, this difference is considered statistically significant. In addition, the results of "askisi" show that this software can provide screening of special learning disabilities so that it can be used in research studies as well as in clinical applications.

Another type of online software for screening dyslexia before the first grade of elementary school is "Serious Games". Dyslexia cannot be screened before the first grades of primary school, because it is linked to reading and writing. For this purpose, there are a number of games aimed at acquiring a skill, which are known as "Serious Games". These types of games are essentially a set of software in the form of a game so that they are more children friendly. In addition, they have been tested in a fairly large sample of children and have been shown to be effective in screening dyslexia in preschool children.

The basic idea of "serious games" is the existence of exercises in order to train both visual attention and speech through a game, so that children improve their learning ability while playing. In addition, these games keep the user interested, so that it is constantly improving and evolving. It has been shown that a child will find it difficult to give up a game if it is interesting, while he is much more likely to give up an exercise that he considers boring. (Maggiorini & Ripamonti, 2011).

Specifically, the above games identify children's abilities in reading skills, and recognition of visual and auditory stimuli (Palazzi et al., 2010). It is worth noting the usability and capabilities provided by "serious games" to users, as they can access through a device that already exists at home (pc, tablet, etc.), whether there is Internet access or not (Facoetti et al., 2003).

Research Gap

The main goal of this research is to create an online assessment software for screening dyslexia in high school children in Greece. The use of computer for screening special learning difficulties is very common in Europe, as it is an economical, fast and quite reliable solution.

Moreover, the use of software is very common for screening large populations. An additional advantage of the web application is that its use does not require specialized personnel unlike the time-consuming process of differential diagnosis.

The originality of this research is the creation of an online application for screening special learning difficulties and in particular dyslexia in students who attend from the 1st to the 3rd Grade of High School in Greece. The user is given the opportunity with a simple internet connection and without the existence of computers with special requirements, the possibility of screening dyslexia in high school students between 12 and 15 years old. The main reason it was created was that in recent years, there has been a large attendance of students for examination at official authorities, so the rapid screening of dyslexia through software can reduce their large number. It is worth noting that software screening cannot replace the official diagnosis made by the specialized staff of official authorities, but its main goal is to identify students who most likely face special learning difficulties.

METHODS

As it has been already mentioned, there was no online software in Greece for screening dyslexia in high school students, as far as the authors' knowledge. For this purpose, the program «DyScreTe» is created. It takes its name from the initials of the words **Dy**slexia **Scre**ening **Te**st and refers to the English word discreet as high school children are old enough and the main purpose was to be tested without feeling stressed.

The DyScreTe application was constructed in accordance with the guidelines for technology-based assessment tests by the International Test Commission and Association of Test Publishers in order to ensure that the assessment is culturally meaningful. The application provides valid and fair assessment which is fundamental for every technology-based assessment test.

Participants

It is worth mentioning that this research has a very important originality. A large enough sample has been collected from the Greek students for the execution of the internet application. In addition, probabilistic sampling was performed and the sample was checked for regularity. An equal dispersion test was then performed. The above tests make the sample capable of drawing conclusions for the whole population and ensure the validity and reliability of the results, that are required in any experimental research. Firstly, pilot research took place, and afterward the main research. In the pilot research, a sample of 60 students from high school in Greece was taken, of which 30 were diagnosed with dyslexia by an official authority in Greece and 30 were typically developed. After the pilot study, a sample of 180 students from high school in Greece was taken, of which 90 were diagnosed with dyslexia by an official authority in Greece and 90 were typically developed.

More specifically, the method of collecting the sample ensured small sampling errors, which makes it representative of its population. In addition, the estimators who interpret the sample data are sufficiently capable of using inferred statistics to draw safe conclusions through the sample in the population. It is worth mentioning that in this research comparisons have been made between the tests in order to ensure their validity and reliability. Predictions were then made between trials, which enhances the ability of "DyScreTe" software to screen dyslexia.

Measures

In this section the research hypothesis of the study is analyzed, the steps of the pilot and main research are described shortly and the assessment tests of the program are analyzed. The main process (pilot and main research) was created to investigate the main hypotheses of our research. To achieve this, it is necessary to gather as much data as possible and describe a sufficient amount of data on the nature and causes of dyslexia. In this context, it was considered that the most appropriate method of investigating the cases is pirate planning. The choice of this method was considered the most appropriate because the research hypotheses contain comparisons and it is necessary to investigate the cause-and-effect relationship between the variables. The descriptive method achieves validity and reliability of the results (Creswell, 2011).

The choice of quantitative research to carry out the experimental procedure is considered necessary and the main reason chosen is that the data collected for its implementation is numerical. In addition, for the completion of the research, it is necessary for the results to be objective and to allow their generalization to larger populations. In addition, in order for the tests to have correct conclusions, there must be a distance between the examined students and the administrators of the software, a condition that can only be achieved through quantitative research (Creswell, 2011).

The model of quantitative research that was followed provides the possibility for in-depth investigation of quantitative data. In addition, an overview of the cases under investigation is provided, which let us generalize the results. Quantitative methodology achieves the comparison and determination of the relationships between the variables under consideration under a universally defined framework of conditions (Creswell, 2011).

Research Hypothesis

According to the literature review, the main hypothesis of this research is that children with dyslexia will show significant differences both in the mean scores and also in the time of completion of all tests, compared to their typically developed classmates.

Then, according to the basic hypothesis analyzed, three sub-hypotheses emerge, according to which it is scientifically proven that the test results will have the correct results at acceptable levels of confidence. Following the literature, such as Skues and Cunningham (2011), and Bonifacci and Snowling (2008), it is expected that children who have already been diagnosed with dyslexia by an official authority will achieve lower scores in all tests, with the exception of the intelligence assessment test (1st Hypothesis). In addition, the research of Van Viersen and co-authors (2015) suggests that children with developmental dyslexia are not expected to have significant differences compared to their typically developed classmates in the intelligence assessment test (2nd Hypothesis). Finally, based on the results of the research of Boets and De Smedt (2010) and Träff and Passolunghi (2015), children diagnosed with dyslexia will complete the tests slower, with the exception of the intelligence assessment test (3rd Hypothesis).

Based on the research hypotheses, the research was carried out in two phases. The 1st phase was the pilot research and the 2nd phase was the main - methodological research.

Pilot research

Based on the research hypotheses, the first phase in which the pilot research was carried out was designed. Pilot research is always the first stage of the research process and is created for research purposes. In essence, it is the previous stage of the main research and the researcher checks the suitability of the tools of the research process. Its main purpose is to test the data collection tools, extend the completion time of the tests and omit parameters in case they do not offer to the researcher process (Bell, 1993). In the pilot research, a sample of 60 students from high school in Greece was taken, of which 30 were diagnosed with dyslexia by an official authority in Greece and 30 were typically developed.

During the pilot research the tests were not administered altogether, but one at a time under the same circumstances. The children did not have a break between the tests and it took about 40-50 minutes for each student to complete all the tests. The children were not assessed and during the test a teacher was present who helped them only if the computer or the internet connection had any technical problem.

The steps followed for the pilot research will be analyzed shortly in the next paragraphs. Initially, both the Greek and the international literature on special learning difficulties were studied and special emphasis was given to the causes of dyslexia. The theoretical background is necessary for the design of tests that will be used to screen dyslexia in high school students.

In the next stage, the tests were structured and planned. The tests were performed in schools, so relevant permission was required. The proposal for the research was submitted to the Ministry of Education and was approved for the school year 2018-2019. By the end of the school year, a sample was collected to carry out the statistical analysis of the data from the students' grades in the software tests.

Main research

In the second phase of the research, all the data from the pilot research were analyzed and the methodological errors were identified. The problems in the tests were identified mainly in the execution times of the tests; additionally, some of them were not so pleasant for the user. Therefore, it was decided that all tests should be performed at the touch of a button without the use of the keyboard. In this way, they do not cost much and are pleasant for the user.

During the main research, the methodological problems were initially corrected and the license issued by the Ministry of Education was renewed for the second school year. In the next stage, in the second school year (2019-2020), the required sample was collected for the execution of our main research. Finally, the statistical analysis was performed and its results were analyzed.

The program DyScreTe

The program includes nine tests. The first test involves pseudowords (nonreal words). Specifically, the pseudowords are displayed on the screen and the child must recognize whether or not the displayed word is a pseudoword or a real one. The reason for this test is that people with direct dyslexia have the ability to read familiar, simple and easy spelling words. However, they cannot read pseudowords correctly and words that they did not use in their speech before a brain injury. Direct dyslexia is the rarest type of dyslexia (Lytton & Brust, 1989). Lyon (2003) states that in the case of direct dyslexia, words are read aloud but their meaning is not understood. It is also difficult for people with direct dyslexia to read low-frequency words or pseudowords.

The second test involves reading texts. Specifically, two texts are displayed on the screen and after each text, there are four questions. In this test, a child's ability to read as well as to understand a text, in relation to time, is tested. Therefore, after the children read the text, they are asked to answer some questions to prove their comprehension. This test is included in the software in light of the fact that reading disorders usually deal with problems in the rapid and accurate decoding of written speech. These disorders can lead to reading comprehension problems that are described as a key feature of a specific reading disorder or dyslexia (Mouzaki & Sideridis, 2007).

The third and fourth tests concern the examination of spelling. The third test concerns historical spelling and the fourth is grammar spelling. In particular, in the third test, a series of twenty words are displayed on the screen where the historical spelling is examined. Thus, in the fourth test twenty words are displayed where the grammar spelling is examined and the student must choose the correct spelling from three choices given. These tests are included because a child, in order to be able to learn to spell, must have acquired the knowledge of letters, the knowledge of the spelling system of his language and have such a memory ability that allows the retrieval of letters and their phonetic correspondences in words with historical spelling (Panteliadou, 2000). At the stage of productive spelling, students have the ability to use spelling rules correctly. Thus, they need to practice more systematically these rules as well as historical spelling. At this stage, students make mistakes that mainly concern historical spelling. Finally, developmental dyslexia is a special learning disability that is presented as difficulty in acquiring reading skills and later as instability in spelling and as a lack of fluency in handling written words.

The fifth test concerns the comprehension of audio texts. Specifically, the student listens to two recorded texts and after each text, he has to answer 4 questions with multiple answers. In dyslexic individuals, the large cell system of the brain malfunctions displays cells smaller than normal. This abnormality seems to affect all the functions with which the large cell system is connected, with the most basic the visual and auditory functions which affect the skill of reading. Therefore, an attempt is made to explain on a neurological basis, the phonological deficits of the case of developmental dyslexia, which no one can deny is present in the entire dyslexic population. Large cell theory, therefore, links deficits in phonological awareness with problems of visual and auditory nature (Reed, 1989; Manis et al.,1997).

The sixth test examines the student's mathematical ability in three areas (known object, arithmetic, and problem-solving). Dyslexic children are unable to memorize basic arithmetic data, retain rules and techniques. Moreover, they have a deficit in recalling arithmetic operations from long-term memory and have difficulty in any task related to numbers (Geary & Hoard, 2001).

The seventh test is a test in which memory and specifically working memory is tested. In detail, students are given a series of thirty-five different letter sequences, where the first sequence contains two numbers, the second three numbers, the third four numbers, the fourth five numbers, the fifth six numbers, the sixth seven numbers, etc. The children will be called to choose the correct sequence of letters from the three options given to them. If a child could not remember two sequences in a row or three sequences in general then the test stops. Plaza et al. (2002) report in their research that children with dyslexia and special learning disabilities perform lower than normally developed children in memory skills. In addition, the short-term working memory in these children presents weaknesses, resulting in difficulty in the sequence and in carrying out activities that require automation.

The eighth test examines visual memory. This test has a number of image patterns that a part of them is missing. The missing part appears on the screen for 4 seconds and then it disappears. The children have to fill in the missing part of a series of pictures given to them. The reason why this trial is included in the program is that in a very recent case study of a 13-year-old boy from Greece diagnosed with dyslexia, Terzopoulos and coauthors (2015) suggest that children with dyslexia have difficulties in visual memory.

Finally, the ninth test examines children's visual ability. This particular test has a series of picture patterns where a part of them is missing. The children had to complete the pattern from a series of pictures given to them. The difference between this and the previous test is that the missing part is appeared on the screen continuously together with the series of pictures given. The reason for this test is previous research that shows that dyslexic students experience short-term memory impairment more when the tests involve schematic representations (Mc Dougall et al., 1994). In addition, children with dyslexia often perform lower in tests that involve the presence of visual perception. Many researchers believe that dyslexic students have a visual impairment and therefore perform poorly on visual tests (Hammond & Hercules, 2000).

A very interesting parameter that is considered with the web application is the measurement of time. In the majority of tests (seven out of nine), the time of their completion is measured. In more detail, a database has been created and time is recorded, which is a very important parameter for screening dyslexia. Students diagnosed with dyslexia are slow readers and have difficulty retrieving information quickly from memory. These weaknesses are recorded over time and contribute to the most reliable screening of dyslexia.

An example of the last test is shown in fig. 1. In this picture, a shape appears above on a blackboard, and under it, four different similar shapes are appeared, at the same time. The student has to choose which of the below shapes is similar to the one shown above.

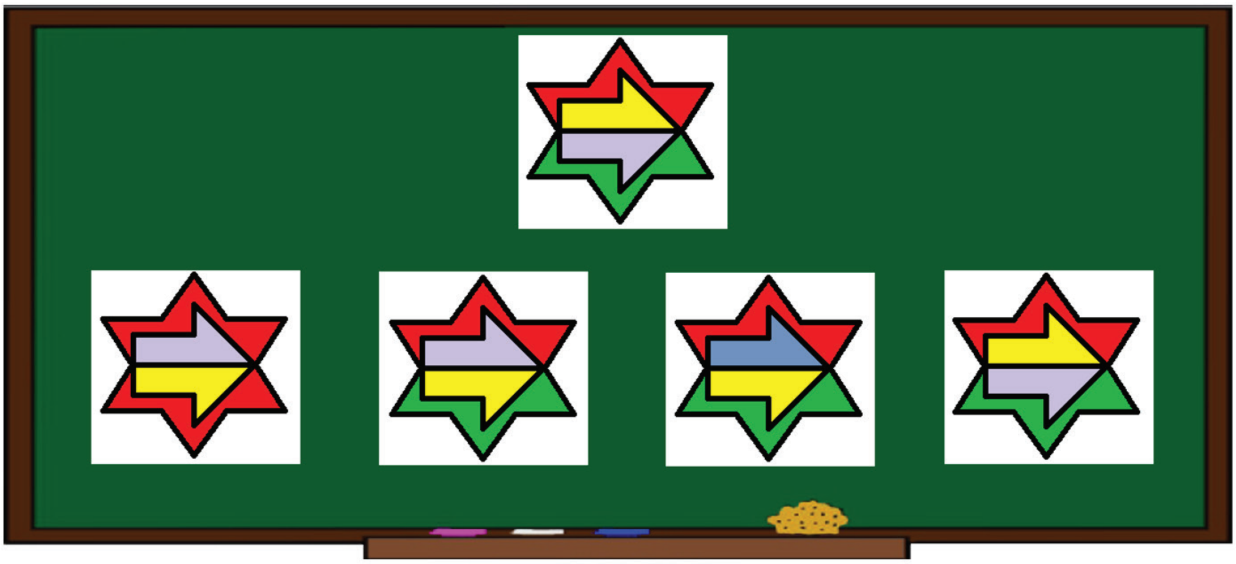

Fig. 1. Example of one visual ability test in DyScreTe

RESULTS

"DyScreTe" is based on the main hypothesis to prove the accuracy of its results. The main hypothesis that was examined is that the children who were diagnosed with dyslexia by official authorities in Greece had significantly lower performance in the respective software tests. During the main research, a sample of 180 students from high school in Greece was taken, of which 90 were diagnosed with dyslexia by an official authority in Greece and 90 were typically developed. The results verified the hypothesis we made that children with dyslexia in each test had a lower performance compared to the typical developed in successful responses. An ANOVA (Analysis of Variance) table was used to compare the results of children with dyslexia with those of the control group, i.e. the typically developed children. The ANOVA table showed that children with dyslexia had a statistically significant ($p < 0.01$) lower average of correct answers compared to the typically developed children in all nine tests as it is shown in Table 1.

Moreover, in Table 2 the time that a child needed to complete each test is presented, for the seven out of nine tests where time was measured. The results verified the hypothesis we made that children with dyslexia in each test needed more time to complete it compared to the typical developed. An ANOVA (Analysis of Variance) table was used to compare the results of children with dyslexia with those of the control group, i.e. the typically developed children. The ANOVA table showed that children with dyslexia had a statistically significant ($p < 0.05$) higher average of time needed compared to the typically developed children in all seven tests where time was counted.

Finally in Table 3 the results of the correlations between the scores of the tests obtained by the students which were tested with the DyScreTe software are presented.

From the results of the above table, it is obvious that there is a correlation between all the tests and specifically a strong positive correlation. In addition, at a level of statistical significance of 5%, the correlations observed

Table 1. **ANOVA table comparing the results of children with dyslexia and typical developed**

TESTS	Dyslectic Children		Typical developed	
	Average	Standard Deviation	Average	Standard Deviation
Pseudowords	15.6	1.54	17.3	1.19
Reading	4.2	0.70	6.9	0.77
Historical spelling	15.8	0.65	18.2	0.77
Grammar spelling	13.9	0.90	16.2	0.94
Listening	4.1	0.60	7.1	0.68
Mathematic ability	15.1	1.53	24.6	1.45
Working Memory	14,0	0,79	27,1	0.80
Visual distinction	7,0	0.82	12,2	0,80
Visual memory	6,0	0,84	13,1	0.80

Table 2. **ANOVA table comparing the results of children with dyslexia and typical developed concerning the time**

TESTS	Dyslectic Children		Typical developed	
	Average	Standard Deviation	Average	Standard Deviation
Pseudowords	1,29	0,25	0,52	0,19
Reading	6,36	0,77	4,25	0,91
Historical spelling	2,63	0,43	1,05	0,29
Grammar spelling	3,27	0,61	1,22	0,33
Listening	3,00	0,46	1,92	0,41
Mathematic ability	13,30	0,75	7,75	0,64
Visual distinction	5,84	0,49	3,22	0,45

Table 3. **Results of the correlations between the scores of the tests obtained by the students**

	Pseudowords	Reading	Historical spelling	Grammar spelling	Listening	Mathematic ability	Working Memory	Visual memory	Visual distinction
Pseudowords	1	0,959	0,722	0,720	0,773	0,882	0,726	0,808	0,815
Reading	0,959	1	0,751	0,771	0,806	0,848	0,872	0,857	0,852
Historical spelling	0,722	0,751	1	0,767	0,802	0,817	0,858	0,845	0,821
Grammar spelling	0,720	0,771	0,767	1	0,710	0,731	0,771	0,751	0,754
Listening	0,773	0,806	0,802	0,710	1	0,877	0,916	0,905	0,884
Mathematic ability	0,882	0,848	0,817	0,731	0,877	1	0,946	0,930	0,913
Working Memory	0,726	0,872	0,858	0,771	0,916	0,946	1	0,966	0,949
Visual memory	0,808	0,857	0,845	0,751	0,905	0,930	0,966	1	0,931
Visual distinction	0,815	0,852	0,821	0,754	0,884	0,913	0,949	0,931	1

Table 4. **The correlations between the time needed for the completion of each test**

	Pseudowords	Reading	Historical spelling	Grammar spelling	Listening	Mathematic ability	Visual distinction
Pseudowords	1	0,979	0,789	0,779	0,759	0,845	0,820
Reading	0,979	1	0,712	0,795	0,878	0,757	0,740
Historical spelling	0,789	0,712	1	0,794	0,890	0,883	0,854
Grammar spelling	0,779	0,795	0,794	1	0,711	0,881	0,863
Listening	0,759	0,878	0,890	0,711	1	0,758	0,722
Mathematic ability	0,845	0,757	0,883	0,881	0,758	1	0,915
Visual distinction	0,820	0,740	0,854	0,863	0,722	0,915	1

are statistically significant. In conclusion, it appears that the tests are consistent in terms of measuring score which is a criterion of quantitative reliability in terms of measurement.

The results of the correlations between the time needed for the completion of each test are presented in the table 4.

From the results of the above table, it is obvious that between all the tests there is a correlation concerning time and in particular a strong positive correlation. In addition, at a level of statistical significance of 5%, the correlations observed are statistically significant. In conclusion, it appears that the tests are consistent in terms of measuring completion time, which is a measure of quantitative reliability in terms of measurement. As it has already mentioned, time was measured in seven out of nine tests of the program.

Concerning the first test (Pseudowords) statistically significant differences were observed between the two groups in the control of the mean values of the students'

Table 5. **ANOVA Table for Pseudowords between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	266,252	1	266,252	141,441	0,000
Within groups	673,909	358	1,882		
Total	940,161	359			

Table 6. **ANOVA Table for Reading between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	657,657	1	657,657	1218,056	0,006
Within groups	193,292	358	0,540		
Total	850,949	359			

Table 7. **ANOVA Table for Historical Spelling between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	532,425	1	532,425	1044,835	0,006
Within groups	182,429	358	0,510		
Total	714,853	359			

Table 8. **ANOVA Table for Grammar Spelling between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	437,606	1	473,606	562,311	0,000
Within groups	301,525	358	0,842		
Total	775,131	359			

Table 9. **ANOVA Table for Listening between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	827,174	1	827,174	2027,344	0,000
Within groups	146,067	358	0,408		
Total	973,241	359			

Table 10. **ANOVA Table for Mathematical Ability between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	8109,1777	1	8109,177	3640,804	0,000
Within groups	797,375	358	2,227		
Total	8906,552	359			

Table 11. **ANOVA Table for Working Memory between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	15400,804	1	15400,804	24365,027	0,000
Within groups	226,287	358	0,632		
Total	15627,091	359			

Table 12. **ANOVA Table for Visual Memory between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	4483,798	1	4483,798	6683,993	0,000
Within groups	240,156	358	0,671		
Total	4723,954	359			

Table 13. **ANOVA Table for Visual Distinction between the two groups (p-value <0.05)**

	Sum of squares	df	Mean Squares	F	sig
Between groups	2388,936	1	2388,936	3637,027	0,000
Within groups	235,148	358	0,657		
Total	2624,084	359			

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scores in the pseudo-words. In more detail, the results are presented in Table 5, where the p-value <0.05, therefore at a level of statistical significance of 5% it appears that the averages between the students of the experimental group and the control group differ.

Statistically significant differences were observed in the control of the mean values of the students' score in reading and understanding texts between the two groups. More specifically, the results are presented in Table 6, where the p-value <0.05, therefore at a level of statistical significance of 5% it appears that the averages between the students of the experimental group and the control group differ.

Similar results concerning historical and grammar spelling are presented in Table 7 and 8 respectively.

Statistically significant differences were observed between the two groups in the control of the mean scores of the students in Listening. More specifically, the results are presented in Table 9, where the p-value <0.05, therefore at a level of statistical significance of 5% it appears that the averages between the students of the experimental group and the control group differ.

Similar results are presented concerning mathematical ability and working memory at Tables 10 and 11 respectively.

Statistically significant differences were observed between the two groups in the control of the mean values of the students' score in the visual memory (recall) and visual distinction as it is shown in Table 12 and 13 respectively.

DISCUSSION

As has been already mentioned, the main goal of the study was the creation of an online program to screen dyslexia in Greek high school students for the first time, according to the authors' knowledge. Thus, the program DyScreTe was created which consists of nine tests that were analyzed shortly in the previous section. In order to prove that DyScreTe was a useful tool to screen dyslexia a large enough sample was taken and the main hypothesis was verified. In other words, according to our results children with dyslexia in each test had a lower performance compared to the typically developed ones in successful responses. Moreover, a very interesting parameter that is considered with the web application is the measurement of time in seven out of nine tests of the program. The results again verified the hypothesis that children with dyslexia needed more time to complete each test compared to the typically developed ones. From our results the program DyScreTe is a useful online application to screen dyslexia in Greek high school students aged between 12-15 years old. The research will be useful to be continued in order to test the program in a bigger sample and it would be interesting for Raven Matrices (Customized Intelligence Test) to be added in order to check students' intelligence and examine the three sub-hypotheses.

CONCLUSION

There are many software concerning screening different types of special learning disabilities. Their main advantage is that they create a pleasant environment for the user. In addition, this software is properly designed to help reduce the stress that can lead to erroneous results. Using a computer, one has the ability to process test data quickly and draw safe conclusions for screening dyslexia, in contrast to the classic clinical trials that require time. For this purpose, the program «DyScreTe» was created, which screens dyslexia in high school children in Greece. This program includes nine tests driven both by the literature and corresponding programs abroad. In the first application of the program in a fairly satisfactory sample it was found that the performance of children with dyslexia was statistically significantly lower than that of children typically developed. In any case, the program cannot replace the assessment by a specialist but is a first indication of whether or not children should proceed with the assessment process.

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