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# Phonological awareness program at school for children with Specific Language Disorders and the role of ICTs

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**Abstract:**The aim of the present study is to implement an intervention program in phonological awareness and verbal working memory in a student with Special Learning Difficulties and to improve the student's cognitive abilities by making a before and after comparison. For the purpose of the present study used the Raven CPM scale, the WISC III, and the Athena Test as psychometric tools to assess the student. The intervention procedure lasted 4 weeks and the student attended 20 sessions for 45 minutes each day. All the activities given to the student were implemented through audio presentation or image presentation. At the end of the intervention, the student was re-evaluated and showed higher scores than the initial evaluation, thus revealing the positive results of an intervention program and showing that there is a relationship between working memory and phonological awareness. These results underline the importance of an appropriate intervention program and show that if it aims at enhancing phonological awareness and utilizes multisensory methods, can improve the levels of working memory that are necessary for the perception and the understanding of language structures, and finally the enhancement of the final acquisition of language.

**Keywords**: phonological awareness, intervention program, working memory, specific language disorder, special learning difficulties

## 1. Introduction

Phonological awareness is a skill that is necessary for the acquisition of language at all levels, as it contributes to the recognition and understanding of the smaller structures of language, such as sounds, phonemes and syllables. By having understood these smaller structures, the person obtains the ability to understand how the combination of these structures work, something that leads to the creation of larger structures [4]. Also, according to the U.S. Department of Education [18, 19], phonological awareness is related to a person's ability to detect or manipulate the sounds of a word, regardless of its meaning. In order to be able to do this, it takes a lot of practice and training of the speaker in this process, because it is a basic skill for acquiring other skills in a later time. Thus, there is a variety of educational activities that focus on teaching the recognition, localization, deletion, analysis, or synthesis of words, syllables, initial and final phonemes, detection, recognizance, and production of rhyme or alliteration [18,19,4]. More specifically, phonological awareness is related to the recognition of the phonemes of the language, which are the smallest structures of the language, while it constitutes a skill that is necessary for the complete and essential acquisition of the language. Phonological awareness, however, is not a skill that is acquired immediately, but is divided into two stages, the overt and the obvious phonological awareness [26]. In obscure phonological awareness the speakers of the language perceive and are able to use the phonemes of the language effectively; however, they are not able to analyze them and understand all their functions. Unclear phonological awareness occurs at a very young age, where children acquire a primary knowledge of language sounds and use them [4]. As children grow older, they move

from the obscure to the obvious phonological awareness, where they are able to understand language more deeply and analyze the structures that form words. At the stage of the obvious phonological awareness, children have metalanguage control and are able to distinguish the smaller structures of language, phonemes, within larger structures, words. Thus, in this phase it can be distinguished which phonemes and syllables a word consists of, but also for the corresponding phonemes and syllables to be combined to create larger structures [1]. Phonological awareness is also directly related to reading and writing skills, as children enter the phonological representations of the language at a very young age as they develop and use the spoken language, while they come in contact with spelling representations of the written language gradually through the education. The more effectively the phonological representations are used, the easier and more correctly the orthographic representations are acquired. Thus, children gradually learn to match each phoneme with its graphic representation and master the writing [20, 26, 27].

Literature review reveals that students with deficiencies of phonological awareness may experience learning disabilities, while students that are diagnosed with Special Learning Disabilities often show significant deficiencies in phonological awareness skills [7, 27, 4]. Reading comprehension, coding and decoding of language structures are considered as essential skills for both reading [11] and writing skills [7], resulting to the fact that students who develop deficiencies in these skills show significant failures in both of these skills [27, 4]. For this reason, students with learning disabilities, which affect their academic progress, are implemented through educational intervention programs, through which the management of students' individual difficulties and the learning of knowledge acquisition strategies are attempted, while at the same time they are designed based on the deficits and the difficulties of students [7]. Thus, many intervention programs are related to the enhancement of phonological awareness and the educational interventions aim at educating the students in the coding and decoding of the language structures, so that the students can show progress in the other structures. Also, phonological awareness is a skill that is acquired relatively early from the speaker, in around preschool age, and for this reason speakers have the opportunity to engage in structured and systematic learning, being trained in reading and writing [26].

On the other hand, a significant protagonist for the acquisition of the language is working memory. Working memory is a system which allows several pieces of information to simultaneously be held in mind in the course of the ongoing activities, while the difficulties are related to incorrect or incomplete coding and decoding of the information that they receive [9]. Working memory is also directly related, as phonological awareness does, to the process of reading, developing and mastering vocabulary, as well as to the ability of understanding the language and the writing [9]. For this reason, many educational programs for special learning disabilities include activities that are aimed at enhancing working memory, so that students are able to cover their deficits and effectively deal with the difficulties that they face in the learning process [7].

In the present study, thus, an attempt is made to investigate the connection between the working and phonological awareness with the acquisition of the language. More specifically, the connection of working memory with language is examined, which is a level of memory associated with the retrieval of information that has been stored and recalled in order fora new knowledge to be acquired.[4, 1].Also, an intervention training program is presented to enhance the above two skills and the results of the interventions are examined in an elementary school student who has been diagnosed with Special Learning Disabilities. Finally, the importance of

phonological awareness for language acquisition is explored, as well as the profile of students who show deficits in phonological awareness.

## 2. The relationship between working memory and the acquisition of language

Working memory is related to the area of the brain where the information that is received is stored for a short period of time, while, in this area, the processing of this information occurs, so that later it can be assimilated, and learning can occur [3,12]. Therefore, based on the role that working memory plays in the assimilation of information, their coding and their assimilation by the individual, its contribution to the acquisition of language gets clear. Students with special learning difficulties, such as dyslexia and innumeracy, show deficits in working memory, so that information they receive from the environment is not properly retrieved, and therefore not stored long term, to be recalled in the future. This inability to store and process information can also lead to deficits in phonological awareness, as speakers are unable to store and process the sounds of the voices, but also their graphic representation [3,12,11]. Also, research has shown that students who experience the aforementioned difficulties, at the same time show significant deficits in working memory, which is directly related to phonological awareness. More specifically, dyslexic students, whether with acoustic dyslexia, visual dyslexia, or mixed dyslexia, are unable to retrieve and store information about phonological and spelling representations, thus leading to not storing the information in the working memory, to then recall them to implement language reading or writing [11,9].

During the years, while researchers were examining the relationship between working memory and language learning and the acquisition of language, they found that there was a significant link between working memory and long-term memory, the area where information is permanently stored and converted into knowledge. which can be reused in case the individual needs it [2]. By exploring the role that working memory plays in language acquisition, various models have been created for how information is retrieved and processed in that area.

Given the importance of phonological awareness in the acquisition of reading and writing, elementary school students show deficits in it have great difficulty in acquiring both skills. More specifically, deficits in phonological awareness are associated with learning difficulties in reading, where students show slow reading, reduced reading fluency, reading errors such as additions, omissions and permutations of letters, syllables or words, accentuation errors and reduced reading understanding. Also, since phonological awareness is related to the acquisition of spelling of phonemes, students who show deficits in it present significant difficulties in writing, where there are spelling errors, additions, omissions, permutations of letters, syllables and words, lack or incorrect intonation and incomplete or no use of punctuation [1,17].

## 3. Intervention programs for the development of phonological awareness

The diagnosis of the difficulties faced by the students and their precise identification, aims at the implementation of some educational interventions with the aim of managing these difficulties and the holistic reinforcement and support of the students. Thus, upon receiving the diagnosis, the interdisciplinary team that evaluates each student designs the intervention program that is related to their individual difficulties and is the guide for the special educators who will implement the intervention. Thus, based on the results of the diagnosis, the difficulties

are identified and the goals that must be achieved through educational interventions are set. Also, intervention programs, as they are designed and adapted to the special needs of students, can take various forms, such as individual programs, group intervention programs implemented at class level and intervention programs implemented in special classes [10]. Finally, taking into account that the intervention programs aim at dealing with the individual difficulties that each student manifests, they are differentiated based on them. For example, one program will be applied to a student who has reading difficulties and a different program will be applied to a student who has written difficulties [27].

A widespread intervention program is the Elkonin method, which aims to enhance students' phonological deficiencies. This method is implemented using cards that contain pictures with objects that are named, and, under the pictures, there are boxes in which students are asked to fill in. This method can be used for students to practice recognizing and distinguishing both phonemes of words and syllables. They can also be practiced for the division and the recompositing of words, while the combination of the word with an image enhances the memorization of the phonological and spelling representation of the word in the working memory [17]. This method can be used of all ages to enhance phonological awareness and becomes particularly effective as students learn to recognize smaller word structures [8].

Also, many programs rely on the use of technology to enhance phonological awareness, which combines image and sound with the acquisition of phonological awareness. These programs, due to the multi-sensory method that they use, can become very effective, as at the same time the working memory is enhanced. For example, the COMPHOT program is an intervention program where students use computers to perform exercises where they are asked to select the image that is mentioned through a recorded voice, while in the image there is also the spelled word that is heard and asked by the child to choose[6]. Another program implemented with the use of technology that can significantly enhance students' phonological awareness is Trainertext, where students are trained in recognizing phonemes and words related to the image and phoneme. However, this intervention program, due to the fact that it is based on reading words and recognizing them, does not significantly enhance spelling [13].

A final intervention program that is implemented again with the use of technology, is the 8 Great Word Patterns [14], where students are trained in creating and recognizing words through patterns of combination of letters and syllables. This program offers a significant enhancement of phonological awareness, thus enhancing the ability to read and spell, as students practice all activities related to the division and reconstruction of smaller structures of language to create larger structures. In fact, in a study conducted by Moser, Morrison, and Wilcox [15], the students that received the intervention due to learning difficulties showed better results than the control group, which included students without learning difficulties.

Based on the aforementioned information, it can be understood that the educational intervention programs implemented in students, are a key factor in managing and addressing the learning difficulties they face and in the overall development and progress of students. During their application, students learn to manage their difficulties, develop learning strategies, that is, methods that help themselves to adequately acquire knowledge, while they are strengthened psychosocially, as the role of the student is strengthened, a role that is very important for all students in whom they wish to be successful. Also, in addition to the ways of managing the difficulties they face through intervention programs and targeted educational

activities applied on a case-by-case basis, students cover some of their shortcomings and gradually build new knowledge.

## 4. Research Purpose of the present study

### 4.1.Object and Aim of Research

The present study is a case study of a 10.4 year old student who is in primary school, whose mother tongue is Greek and was diagnosed with dyslexia-dysgraphia, without recognizing any sensory deficits for the difficulty in writing. The additional difficulties that the student faces are described by KESY as disturbances in the stereotypical movements and a depressive background with a dense description. KESY is an educational and counseling center, which operates as the public body that implements assessments related to the learning difficulties faced by students in order to design intervention programs to address the difficulties and support the educational unit in which they attend. This assessment is carried out by an interdisciplinary team that evaluates students in all areas and which consists of a pediatric developmental specialist, a child psychiatrist, a child psychologist, a social worker and a special educator. In cases of difficulties that are related to speech and language, but also to the mobility of students, specialties such as a speech therapist and a physiotherapist may be added to the group. An intervention program was implemented for the student that aimed at enhancing his phonological awareness. The aim of the research is to investigate the connection between working memory and phonological awareness and whether educational interventions that are aimed at these two areas can enhance the acquisition of the language as well as the working memory capacity. In order to make the research easier to implement, three objectives were formulated on which the interventions that were designed and implemented in the student were based, and which at the end of this intervention were evaluated in order to evaluate the intervention as a whole. The aims created are the following:

1. Improvement of the performance of phonological works through the implementation of the intervention program.

2. Improvement of the student's performance in the tools for measuring working memory through his training in mnemonic strategies.

3. Improvement of the student's reading profile through the implementation of the intervention program.

## 5. Research Methodology

Concerning the research with the cognitive intervention program in phonological awareness and Verbal Working Memory that aims to improve the student's cognitive abilities –making a before and after comparison -, the Raven test was administered - specifically the CPM- to assess the student's non-verbal intelligence, the WISC III and the Athena tests, from which selective scales were administered respectively for both tests. The tests were handed out in the integration department, in a clean, quiet place and on a white table with a smooth surface. The scales were administered according to the instructions of each test separately.

During the assessment, the student was cooperative and willing, and throughout the assessment sat opposite the assessor. Raven's process was presented to the student as a game where he was

asked to select a piece that was missing from the color image each time. In this way, the student's interest remained undiminished. The process longed for 15 minutes. The answers, as well as the relevant comments, were written down in the Raven test answer sheet. This was followed by the administration of WISC-III using scales to assess short-term and working memory. This process longed for 10 minutes. Finally, the Athena test and the scales for the category "grapho-phonological awareness" were administered, too.

## 6. Research Sample

The research that was conducted by the researcher is a case study. For its implementation, there was selected a Greek student that was 10.4 years old, who is studying at the 5th grade of elementary school and has been diagnosed with Special Learning Disabilities. More specifically, the respective KESY that evaluated him diagnosed the student with Dyslexia-Dysgraphia and, in addition, he was diagnosed with difficulties in stereotypical movements and a depressive background with low intensity, due to the difficulties he faces.

## 7. Tools of Initial Assessment

The first assessment tool that was given to the student in the study was Raven's Educational CPM / CPS psychometric tool. The tool provides in a short time non-verbal and verbal assessment of the general mental ability of children aged 4-12 years. Raven includes 2 scales: the Colored Progressive Matrices- CPM and the Crichton Vocabulary Scales- CVS

For the present case study, it was considered appropriate to use the Raven CPM scale to ensure the student's mental potential. The CPM scale investigates non-verbal skills, that is, the ability of the individual to take out his conclusions in a visual-spatial context, the ability to make sense through a confusion, the perception of what is not immediately visible, that is, to make sense of complexity, also known as the inductive capacity and the reproductive capacity of information and the formation of large non-verbal structures that facilitate the handling of complex problems involving interdependent variables [16].

The CPM scale consists of puzzles that are diagrammatic and designed to assess more accurately the mental processes of young children in particular. It can be used for people from different cultural backgrounds, but also with those who speak different languages or impose language difficulties [16]. The CPM rating includes 3 sets of 12: A, $A_b$ and B, 36 items. The test presents colored printed illustrations, with the smallest possible verbal explanation. As the child only needs to show that one image that completes the drawing correctly to solve the problem, this particular handling of the material is not ideal for the success. The CPM scale takes 15 minutes to describe and evaluate the child. The elements are organized in order of the extent of difficulty. In order for the scale to be maintainedand validated, it is clear to observe the uniformity of the indication, the grading procedures, and the evaluation procedures [16].

The second assessment tool that is used is WISC III, which is a psychometric tool that is suitable for assessing children aged 6 to 16 years. This psychometric tool, which has been used also in the Greek population, consists of 6 verbal and 7 practical sub-scales, each of which examines a different aspect of intelligence (logical abstract thinking, short-term auditory memory, working memory, comprehension, fluency, spatial perception, visual-motor coordination, writing-motor ability, etc., with the results of a psychometric index known as the

"General Intelligence Quotient", which comprehensively expresses the child's mental potential. Information is also drawn on the personality traits of the child that may have a negative effect on his/her progress-performance [5].Given that the student has specific deficits in memory, the sections related to his individual deficits were selected from the psychometric tool. Thus, the student was given activities of recall of digits, which examine the short-term memory and how to hold the coding of this information. In these activities, the evaluator mentioned to the student some numbers which he then asked for them to repeated, in order to evaluate the degree of storage of information in short-term memory and the degree of its recall. The student was also given activities that assessed the performance of working memory and were related to reverse digit recall activities.

Finally, the third assessment tool that was given to the student was The Athena Test. This psychometric tool consists of a series of diagnostic tests for the evaluation of processes - mental, perceptual, psycho-linguistic and motor- which are related to the difficulties that children have in trying to succeed with their school activities [24]. The results of the tests can reveal the areas where problems occur, problems that make difficult for the child to respond to school activities and to consider a therapeutic intervention as necessary [23]. The Athena Test includes a total amount of 14 tests, while there is an additional supplement. These challenges shape the scales of the test and they are divided according to the field they are being evaluated. More specifically, the scales of the test are "Mental ability", "Immediate memory of sequences", "Completion of performances", "Grapho-phonological awareness" and "Neuro-psychological maturity" [23]. This tool can be provided by the evaluator in three ways, depending on the field that he/she wishes to evaluate. The first way concerns the complete administration of the test, where the students are evaluated in all activities; the second way is the short administration, where there are given to the students 6 scales out of the 11 and 1 quality scale in students of kindergarten and first class of primary school or 2 in the older children. Its total duration is 45 minutes and takes place in one meeting [24]. Finally, the third way is related to the selective administration of the test, depending on the difficulties experienced by the students and the areas in which the assessor wishes to focus. Selective administration is commonly used in research or in students with sensory and motor difficulties [24]. In the present research, there is used the selective evaluation of the Athena test scales, which were administered after Raven and had to do with the sequence memory and the grammatical-phonological awareness of the student. More specifically, the student was evaluated in the category "grammatical-phonological awareness" in the scales of graph discrimination, sound discrimination and sound composition, in "graph discrimination", in "sound discrimination" and in "sound composition". With these activities, the assessor aimed to explore how the student perceives and can distinguish the smallest structures of language, such as phonemes, graphs, and syllables, and how they are reconstituted for the words to be created later.

## 8. Results of Student's Initial Assessment

The initial CPM results for the non-verbal intelligence of the 10.4-year-old student are as follows:

Sub-scale A = 8 out of 12, Sub-scale AB = 11 out of 12 and Sub-scale B = 12 out of 12 with a total initial grade = 31 out of 36.

Typical grade 110 and 75 cm, with equivalent age 11.

The WISC-III score on the serial digit recall (short-term memory) was 17 out of a maximum of 16 and on the reverse digit recall (working memory) was 5 out of a maximum score of 14;a total of 22 points out of 30 points for a maximum value.

The results concerning the Athena test, where the student was assessed in the category of "grapho-phonological awareness" in the scales of graph division, sound division and sound composition showed a marginally high performance in "graph division" and a marginally low performance in "sound division" and "composition of sounds". This category refers to the degree of the student's awareness that written and spoken speech is constituted of basic sub-visual and auditory units: phonemes-phonograms, graphs-letters.

## 9. Educational Intervention implemented on the student

Based on the results of the evaluation that was extracted from the application of the above psychometric tools, the results showed that the intervention of the student had to focus on strengthening the student's cognitive abilities, reading, and working memory. Thus, an individualized intervention program was structured, based on the student's profile. The intervention started on February 14 and, until March 5, 3 weeks went by. Due to the illness of the student after the 5$^{th}$ of March and the closure of schools due to COVID-19 quarantine measures, the intervention stopped after 3 weeks and continued on the 5$^{th}$ of June with its completion on the 19$^{th}$ of June.

The weeks when the program was implemented were divided among the areas that seemed necessary to be strengthened and, in each session, specific activities were implemented to enhance the skills of the student. The most significant long-term objectives of the intervention that was made were the:

- Enhancement of phonemic awareness
- Cultivation of phonemic division (acoustic division)
- Improvement of acoustic division
- Enhancement of working memory through audio information (verbal way)
- Enhancement of verbal working memory with visual information and support (use of images)

During the first week of the intervention, which initially focused on enhancing the student's phonetic awareness, there were used activities related to the division and synthesis of words into syllables. Activities related to acoustic division of sigmoid consonants were then used to cultivate phonemic awareness at the level of the individual sound. Then, in the second week, the intervention focused on enhancing phonological awareness, where activities were utilized for the students to break down words into syllables in order to understand the structures of smaller words. Then, in the third week, the intervention activities focused on enhancing phonological awareness again through the reading of pseudo-words and words and through activities, where the student had to implement acoustic division between momentary and continuous consonants. Finally, in the fourth week of the intervention, the activities that were implemented aimed at strengthening the phonological awareness at the level of syllables. The activities that were given to the student included splitting words into syllables and then composing words from those syllables, while there were also exercises where the student had

to find and recognize the initial syllable of the words that were given to him. All the activities given to the student were implemented either through audio presentation or through presentation by using images.

## 10. Results of the Intervention

At the end of the intervention, the student was re-evaluated on the scales that were used in the initial evaluation, in order to compare the results and evaluate the level of the success of the intervention. The results of the re-evaluation are as follows:

- The final CPM results for the non-verbal intelligence of the student aged 10.9 years old were as follows: Sub-scale A = 10 out of 12, Sub-scale AB = 11 out of 12 and Sub-scale B = 12 out of 12 with a total initial grade = 33 out of 36. Typical grade was 115 and 84 cm, with an equivalent age> 11.
  Difference: initial grade 33 out of and 115 out of 115 standard grade.
- The score of WISC-III in serial digit recall (short-term memory) was 17, as in the initial evaluation; in reverse digit recall (working memory), it was 8 to 3 points higher than the original. In total, it was 25 points out of 30 points of maximum value.
- The results for the Athena test, where the student was evaluated in the category "grapho-phonological awareness" in the scales of graph division, phonogram division and phonogram composition showed a marginally high performance (the developmental quotient was 12 with chronological age 10.4) in the "graph division", as it was in the initial assessment, a marginally low performance in "sound division" with a 1 point increase in developmental quotient 8 out of 7; in the topic of "sound composition", the child's developmental quotient reached an average performance from a marginally low by 3 points in a developmental quotient, that is 10 out of 7.

## 11. Discussion-Conclusion

In conclusions we have to underline the role of digital technologies in intervention and education domains that is very productive and successful, facilitates and improves the assessment, the intervention and the educational procedures via Mobiles [34-51], various ICTs applications [52-107], AI & STEM [108-124], and games [125-142]. Additionally the combination of ICTs with theories and models of metacognition, mindfulness, meditation and emotional intelligence cultivation [143-211] as well as with environmental factors and nutrition [28-33], accelerates and improves more over the results of the rehabilitation and educational practices, especially for children with language disorders.

More specifically the present study is a case study of a student who was diagnosed with Dyslexia-Dysgraphia. An intervention program was implemented for this student, which was based on the enhancement of working memory through activities related to phonological awareness. The results of the research showed that there is a relationship between working memory and phonological awareness, as the intervention program that was implemented and was based on strengthening and improving the student's phonological awareness showed successful results. The results of the research, being both qualitative and quantitative, showed that the enhancement of phonological awareness can enhance working memory, so that the student is able to distinguish and synthesize words and their structures more easily, while it is possible, too, to encode and decode on a better way the information that are received both in

an audio and optical way [11, 9]. Based on the results of the present study, which are consistent with the results of previous researches in the field of connecting working memory with phonological awareness, it is shown that intervention programs aimed at enhancing phonological awareness, which utilize multisensory methods, are able to improve the levels of working memory [6], something that is considered necessary for the perception and the understanding of language structures, and ultimately the enhancement of the final acquisition of language [4].

## 12. Research Limitations

The Interventional Program that was proposed in the research was for 6 weeks with 45 minutes each day with the suggested activities. However, due to the COVID-19 situation and the quarantine that closed every school in March, but also the absence of the student due to an illness, the intervention was done for 4 weeks. A total of 45 minute sessions were performed, which included activities to cultivate and enhance phonemic awareness, improve auditory discrimination, and enhance verbal working memory. Due to the health limitations that were imposed, the results that were obtained from the intervention program are not able to be generalized to characterize the success of the program; however the present research may be the trigger for a more comprehensive future research, where the activities of the program will be fully implemented and the results will be effective and more complete.

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