A diagnostic approach of developmental dyslexia based on the types of errors on written texts of greek children

Andreas N. Bessas[126]

Abstract

The dyslexia studies examine the process of writing in children in order to explore the causal factors leading to dyslexia, the clarification of symptoms and the attendant disorders. They proclaim the existence of a close relationship between the symptoms of dyslexia and the abilities of processing input, language, senses, perception, attention, memory, as well as the development of speech in pre-school years. The present study aims at locating the errors in writing that constitute the diagnostic criteria for the classification of dyslexia. The categorization of errors in groups leads to the location of the respective types of dyslexia. The errors in text writing can be categorized in groups, according to the disorder in the acoustic-cognitive, visual-spatial or linguistic process of information. Developmental dyslexia can be categorized in forms of acoustic, visual and linguistic dyslexia, as well as a mixed form, according to the errors the children present in text writing.

Key-words: Developmental dyslexia, Writing errors, Acoustic/visual -cognitive disorder, Linguistic disorder

[126] Speech and Language Pathologist, MSc.

Introduction

Dyslexia has been an object of study for the global scientific community for more than a century. Current studies examine the process of writing in children in order to explore the causal factors leading to dyslexia, the clarification of symptoms occurring in children and the attendant disorders that affect the course of children in school. The study results proclaim the existence of a close relationship between the symptoms of developmental dyslexia and the abilities of processing input, language, senses, perception, attention, memory, as well as the development of speech in pre-school years.

Boder (1973) suggests a classification among dyslexic children based on reading spelling errors. She claims that "most of the errors made by dyslexic children do not occur at random, but in patterns of errors". Great interest appears in the dissociation of classic dyslexic errors in dysphonetic and dyseidetic errors. The first ones, according to Boder, can be "valuable diagnostic signs, as they distinguish subtypes among dyslexic children". Bartelson (1986) explains that "dysphonetic dyslectics' deficiencies lie in deciphering skills, while dyseidetics' deficient in visual recognition".

Based on the same principle we will try to record the errors made in text writing in Greek language and locate the various types of developmental dyslexia that appears in them. Based on current studies on developmental dyslexia, the errors of children's writing and reading a text are classified in three categories:1) acoustic errors (errors due to deficit in acoustic-cognitive processing of information), 2) visual errors (errors due to deficit in visualspatial processing of information) and 3) linguistic errors (errors in linguistic processing of information). A review of studies helps us understand the findings that lead to the conclusion of a complex etiology and pathology not only in children but in adults with dyslexia as well.

Generally, the studies made, have come down to two directions. One of them examines the brain's structure and function, as well as the functions related to its parts, while the other one examines both the previous items and how they affect or they are affected by the dyslectic children's typical symptoms. In order to develop our study, it is advisable not to examine the researches that deal with the neuropsychological patterns of our brain. What really concerns us is the learning analysis and the cognitive

functions that affect it, as well as the way through which the information is processed by dyslectic people and what the symptoms they lead to are.

Ziegler (2008) report a "complex pattern of phonological, phonetic and letter processing deficits" in children with dyslexia. Cognitive psychologists investigated visual perception, visual memory, cross modal transfer between visual and verbal codes and perceptual learning and other skills in relation to reading ability (Snowling, 2004). Some researchers propose a perceptual basis for the disorder; others postulate a linguistic source of the problem (Mycroft, Behrmann, & Kay, 2009). Explaining this suggestion, Muter (2004), mentions that "the learning to read task is to learn the mapping between the representation of written words (orthographic units), spoken words (phonological units) and their meaning (semantic units)". Durand et al. (2005) report "verbal ability as predictor of variations in arithmetic skills and unique predictor of variations in reading skills". In addition, according to Ramus (2003, 2004) "dyslexia seems best characterized as a specific phonological deficit, optionally accompanied by a sensorimotor syndrome".

The perceptual and linguistic bases for the disorder are examined by studies that show their relation to reading and writing ability. Caravolas, Hulme, & Snowling (2001) mention that "spelling requires phonological transcoding ability for the formation of orthographic representations" and Zaidel (1981) "phonetic recoding as a necessary skill for sentence reading". The cause of the dyslexia's appearance is considered by many people to be "the phonology-based word recognition processing low ability" (Lavidor, 2006), where "the phonological decoding mechanism operates extremely slowly and serially" (Ziegler, Perry, Ma-Wyatt, Ladner, & Schulte-Korne, 2003) and requires "phonological decoding skills, in addition to motor skills" (Rae, 2002). According to Castles (2009) "phonemically trained children appear advantage on recognition tasks".

Blomert & Mitterer (2004) find deficits in the phonetic transform to lexical/phonological representations, while according to Hulme, Goetz, Gooch, Adams, & Snowling (2007) "visual learning (orthography) to phonological mappings is an important skill for developing word recognition skills in reading". Reading often relates to "orthographic decoding" (Barber & Kutas, 2007), "perceptual decomposing of the word stem prefix and suffix morphemes" (Mano, Osmon, & Klein, 2005), "disorder of

the processing or transfer of information within the cerebellar cortex" (Baillieux, Vandervliet, Manto, Parizel, De Deyn, & Mariën, 2009)

Johnston & Watson (2004) explain the important role of sounding and blending's technique, in order to expand their reading vocabulary by decoding the unknown words they encounter when reading text. According to Schulz, et al. (2008) "sentence reading is impaired in dyslexic readers, but whether semantic processing deficits contribute is unclear".

Sound to letter mapping is being analyzed in many studies and proves its influence on dyslexic children. According to Ziegler (2006) children in all languages need to develop appropriate symbol–sound mapping in order to learn to read; in alphabetic languages, children learn to map letters onto phonemes while in logographic languages complex graphic-motor mapping onto whole-word phonology is necessary. Caravolas, Kessler, Hulme, & Snowling (2005) underline the role of grapheme-phoneme correspondences, while Serniclaes, Van Heghe, Mousty, Carre, & Sprenger-Charolles (2004) claim that core deficit in dyslexia may be affect mapping between graphemes and phonemes. According to Snowling (1980) dyslexics have a specific difficulty in grapheme-phoneme conversion, while Sarkari (2002) defines dyslexia as functional deficit in the neural circuit that mediates the conversion of print to sound. More particularly, dyslexics show difficulties in phonology-to-orthography and orthography-to-phonology conversion which co-occurs with semantic errors in reading and writing to dictation (Alario, Schiller, Domoto-Reilly, & Caramazza, 2003), with a preferential use of the sublexical print-to-sound correspondence rules (De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002). Castles, Coltheart, Wilson, Valpied, & Wedgwood (2009) mention that phoneme or letter awareness directly assist learning of letter–sound correspondences, while Mody (2003) supports that poorly defined phonological categories may interfere with the development of grapheme–phoneme correspondences.

Explanations related to acoustic function deficits appear in various bibliographic sources. Heim, et al. (2000) report differences in the "organization of their left-hemispheric acoustic cortex", while Paul, Bott, Heim, Eulitz, & Elbert (2006) add that "cortical acoustic (language) processing is organized differently in dyslexic subjects". Boets, Wouters, van Wieringen, & Ghesquière (2006a, 2006b) found that "the relation between acoustic and phonological skills seems to be much less straightforward" and

“an exclusive relation between acoustic spectral processing sensitivity and phonological skills”.

Researches locate acoustic perception problems in dyslexic and analyze their relation to other abilities. Alain, et al. (2005) mentions “speech perception problems in dyslectics”, Boets, Wouters, van Wieringen, & Ghesquiere (2007b, 2007a) indicate “the low-level acoustic and speech perception problems” and discover “relations between aspects of auditory processing, speech perception and phonological ability”, Bogliotti, Serniclaes, Messaoud-Galusi, & Sprenger-Charolles (2008) confirm “the relationship between reading skills and speech perception”, Gerrits and de Bree (2009) support the existence of “lower speech perception and production performance in children at familial risk of dyslexia”, while Hickok, et al. (2008) point out that fails in the comprehension of speech sounds often leads to semantically-based errors.

Phonological deficits seem to relate to dyslexia. Mody (2003), Schulz, et al. (2008), Beaton (2004) and Paulesu, et al. (2001) mention phonological deficits in dyslexics, Beaton (2004) indicates phonological problems with speech perception or discrimination problems in some dyslexic children and adults, Boets, Wouters, van Wieringen, & Ghesquiere (2007b) define the core of the reading and spelling problem at the level of higher-order phonological processing, Bednarek, Saldaña, & García (2009) report the “relationship between performance on phonological tasks and reading skills”, and Bonte & Blomert (2004) that “there is an anomalous contribution of phonological information to the processing of spoken words, which may be related to time-course aspects of phonetic/phonological processing”.

On the other hand, various researches analyze the relation between the visual perception and dyslexia, giving a completely different extent to the problems dyslectic people face. Beaton (2004) points out that visual deficits associated with reading difficulties have often been seen as contradicting the view that phonological deficits constitute the core causal problem in dyslexia, while Evans (2004) suggests that “visual factors causing reading difficulties is rather less compelling than phonological factors”. Mycroft, Behrmann, & Kay (2009) point out “a significant visuoperceptual impairment in letter-by letter reading that adversely affects reading performance as well as performance on other non-reading tasks”, Lorusso, Facoetti, Pesenti, Cattaneo, Molteni, & Geiger (2004) support “a general characteristic of visual perception, and possibly a

different visual-attentional mode" in dyslexia, while Barber & Kutas (2007) explain that "the visual (or word) processing system could segment words into a variety of sublexical units, associated with different information types (phonological, syllabic, morphological)".

According to Corbetta (2001) dyslexia involves attentional and visual perceptual deficits, while Facoetti & Molteni (2001) add that "the deficit of the mechanism subserving spatial attention might determine some visual perceptual disorders in dyslexia". Boets, Wouters, van Wieringen, & Ghesquiere (2007b) report that "visual magnocellular problem might independently contribute to the development of literacy problems", while Talcott, Hansen, Assoku, & Stein (2000) claim that "developmental dyslexia has been associated with multisensory deficits for dynamic stimulus detection". However, Kevan & Pammer (2008) claim that "the dorsal visual deficits observed in dyslexic readers are unlikely to be the result of reading failure".

A different theoretical approach implies a relationship between language deficits and dyslexia. According to Alario, Schiller, Domoto-Reilly, & Caramazza (2003) "phonology and orthography are directly involved in the process of lexical selection". Snowling (2004) suggests that there are problems with long-term verbal learning in dyslexic children responsible for the poor vocabulary development, whereas Nicolson, Fawcett, & Dean (2001) claim that language-related skills disorders can cause the impairments in reading and writing. Furthermore, Boets, Wouters, van Wieringen, & Ghesquiere (2006b) support a relation between coherent motion sensitivity and orthographic skills.

Other researches examine the relationship between memory and dyslexia. Gunnell & Parlow (2008) associate "poor phonological processing with poor working memory", Sotozaki & Parlow (2006) report that " reading problems may stem from the word retrieval process from the long term memory", Muter (2004) suggest a consideration of the interaction between phonological skills with verbal memory processes, Pickering (2004) discovers problems with memory tasks involving phonological material, whereas Suk-Han Ho, Chan, Chung, Lee, & Tsang (2007) claim that in dyslexia more basic skills are involved, such as phonological working memory and long-term representations of phonology.

According to the previous recent studies on dyslexia, we can assume that dyslexic children face three basic problems, either these are the cause of dyslexia or rather its result. As a result, we have come to the conclusion that there are three different forms in dyslexia's appearance, the acoustic form, the visual form and the linguistic form.

Experiment

The present study aims at locating the errors in written texts that constitute the diagnostic criteria for the classification of dyslexia in 3 different categories: acoustic, visual and linguistic dyslexia. The categorization of errors in groups of acoustic, visual and linguistic errors leads to the location of the respective types of dyslexia, which are analyzed according to the gender and grade of the children.

The investigation uses the following methods: dictation of text, copy of text and free writing of text by description of a subject picture.

Subjects: To identify the types of errors in writing are generally studied 137 children with dyslexia from 2nd and 3rd grade who attend regular schools, 77 of which are boys and 60 girls, 72 children in 2nd and 65 in 3rd grade. 2nd grade has 43 boys and 29 girls and 3rd grade 34 boys and 31 girls. 46 children are 7 years old (y.o.), 28 boys and 18 girls, 64 children are 8 y.o., 30 boys and 34 girls and 27 children are 9 y.o., 19 boys and 8 girls, 46 7 y.o. and 26 8 y.o. children in 2nd grade, 38 8 y.o. and 27 9 y.o. children in 3rd grade.

Materials: For implementation of the experiment are used texts from the school textbooks for the 2nd and 3rd grade. Periods of the experiment were chosen so that the texts have already been taught to the children.

Procedure: The first text is given to the child for dictation with the instruction to write the text that will be dictated by the examiner. Examiner dictates every time no more than 3-4 words. Second text is given to the child in printed form with the instruction to copy it. For the description a black and white picture is selected, which depicts a playground and the child is given the instruction to write what he/she sees.

The time of the study was set at 15 minutes for each text, but some of the children needed more time for the copy from dictation or description of the picture, so the examination time differs from child to child.

Identification criteria: Identification criteria are the errors of children admitted in writing. Written texts are checked and the errors that have been described in each table

are labeled in a certain way. Errors are grouped according to their individual characteristics, based on sound, visual or linguistic deficiency etiology.

To determine the forms of dyslexia from the errors in writing of text the sum of words written by the children and the errors in text writing are count. In order to find the ratio of appearance (RA) of the different types of errors in writing the following formula is used: $RA_{(current\ type\ errors)}$= sum of current type errors / sum of written words

Dominant acoustic, visual and linguistic errors is assumed when RA>50%, symbolized with a capital letter ("*A*" for acoustic, "*V*" for visual or "*L*" for linguistic). Nondominant acoustic, visual and linguistic errors is assumed when RA>10% and RA≤50%, symbolized with a small letter ("*a*" for acoustic, "*v*" for visual and "*l*" for linguistic). When RA≤10% errors are considered as random with unknown etiology. The combination of the identification letters represents the dyslexia's subtype. In the current experiment 3 clean forms of dyslexia (*A*, *V* and *L*), 9 dominant subtypes of dyslexia (*Av*, *Al*, *Avl*, *aV*, *Vl*, *aVl*, *aL*, *vL* and *avL*) and 4 mixed subtypes (*av*, *al* and *avl*) are obtained. In order to investigate the differences between the forms of dyslexia, hereinafter "acoustic dyslexia" (AD) will mean clean acoustic (CAD) and dominant acoustic dyslexia (DAD); "visual dyslexia" (VD) will mean clean visual (CVD) and dominant visual dyslexia (DVD); "linguistic dyslexia" (LD) will mean clean linguistic (CLD) and dominant linguistic dyslexia (DLD).

Data analysis: In this particular experiment, therefore, that the data follow a regular distribution for the analysis was used the distribution of $\chi 2$. For implementation of this analysis the number of errors that children made for different types of text are collected and analyzed by gender, class and age of children during the study.

Results

The experiment includes data from the texts of 137 children in 2nd and 3rd grade. From total 77 boys and 60 girls, 72 boys and 55 girls have valid cases for acoustic errors (AE), 42 boys and 25 girls have valid cases for visual errors (VE) and 76 boys and 57 girls have valid cases for linguistic errors (LE). For AE the boys' mean is 10.28 and the girls' 7.13; for VE the boys' mean is 2.76 and the girls' 2.76; for LE the boys' mean is 13.63 and the girls' 9.07. From total 72 2nd grade children and 65 3rd grade children, 66 2-grade and 61 3-grade have valid cases for AE, 39 2-grade and 28 3-grade have valid cases for VE and 69 2-grade and 64 3-grade have valid cases for LE. For AE

the 2-grade mean is 9.42 and the 3-grade 8.36; for VE the 2-grade mean is 3.21 and the 3-grade 2.14; for LE the 2-grade mean is 10.86 and the 3-grade 12.56.

From total 136 children identified as dyslexics, 77 are boys and 59 girls, 43 boys in 2nd grade and 34 in 3rd grade, 28 girls in 2nd grade and 31 girls in 3rd grade, 28 7 years old (y.o.) boys, 30 8-y.o. boys, 19 9-y.o. boys, 18 7-y.o. girls, 33 8-y.o. girls and 8 9-y.o. girls. 2nd grade has 7-y.o. (little 2nd grade) and 8-y.o. children (big 2nd grade), while 3rd grade has 8-y.o. (little 3rd grade) and 9-y.o. children (big 3rd grade). 4 little 2nd grade boys, 4 big 2nd grade boys, 5 little 3rd grade boys, 7 big 3rd grade boys, 4 little 2nd grade girls, 3 big 2nd grade girls and 5 little 3rd grade girls are identified as Acoustic Dyslectics. 15 little 2nd grade boys, 8 big 2nd grade boys, 9 little 3rd grade boys, 9 big 3rd grade boys, 10 little 2nd grade girls, 2 big 2nd grade girls, 14 little 3rd grade girls and 6 big 3rd grade girls are identified as Linguistic Dyslectics. 1 little 3rd grade boys and 1 little 2nd grade girls are identified as Visual Dyslectics. 9 little 2nd grade boys, 3 big 2nd grade boys, 3 big 3rd grade boys, 4 little 2nd grade girls, 4 big 2nd grade girls, 4 little 3rd grade girls and 2 big 3rd grade girls are identified as Mixed Dyslectics.

Forms, types and subtypes of dyslexia

The forms of dyslexia are acoustic (AD), visual (VD), linguistic (LD) and mixed (MD) form. This particular research shows that 33 children can develop AD, 2 children can develop VD, 71 children can develop LD and 30 children can develop MD.

The types of dyslexia are clean acoustic (CAD), dominant acoustic (DAD), clean visual (CVD), dominant visual (DVD), clean linguistic (CLD), dominant linguistic (DLD) and mixed dyslexia (MD). This present research shows that 2 children can develop CAD, 31 children can develop DAD, 2 children can develop DVD, 9 children can develop CLD, 62 children can develop DLD and 30 children can develop MD.

Analysis of different types of errors in relation with gender and education level

In order to explore the relationship between the sum of the different types of errors in writing and children's gender a distribution of $\chi 2$ was conducted. Statistical analysis of AE, VE and LE in the writing of text depending on the gender of the children shows that there are statistically significant differences ($\chi 2=6.65$, $df=2$, $N=54$, $p=.038$), so that gender affects the types of errors in writing of text, and specifically the AE, with the

boys to do most of them. Differences in boys and girls are significant and the boys have approximately 2 times more errors when writing a text than the girls. VE and AE of boys have the same proportion. In writing of text the boys are expected to make many more errors. The AE have biggest frequency, which is almost as VE and LE together. However, this is not depending of the gender, because the sum of VE and LE in the girls was close to the number of AE, something which appears in boys too.

In order to explore the relationship between the sum of the different types of errors in writing and children's grade a distribution of $\chi 2$ was conducted. Statistical analysis of AE, VE and LE in the writing of text depending on the education level of children shows that there are no statistically significant differences ($\chi 2$=1.80, *df*=2, *N*=60, *p*=.405), so that the education level does not affect the types of errors in writing of text by the children. Errors of children at 2nd and 3rd grade do not have significant differences. Children while writing a text are expected to make the same mistakes as children in 2nd and 3rd grade. The sum of errors changes very little during increase of the level of education.

Table 1

Analysis of errors in different forms of dyslexia in relation with gender and education level

In order to explore the relationship between the sum of errors in different forms of dyslexia and children's grade a distribution of $\chi 2$ was conducted. Statistical analysis of forms of dyslexia depending on the gender of the children shows that there are statistically significant differences ($\chi 2$=58.22, *df*=3, *N*=54, *p*<.001), so that the gender affects the errors in different forms of dyslexia, and specifically the errors in LD, with the boys to do most of them. Boys with AD, VD and MD make more errors, while in children with VD more errors are made by the girls. This may be due to the little number of children with this form of dyslexia.

In order to explore the relationship between the sum of errors in different forms of dyslexia and children's grade a distribution of $\chi 2$ was conducted. Statistical analysis of forms of dyslexia depending on the education level of children shows that there are statistically significant differences ($\chi 2$=242.21, *df*=3, *N*=60, *p*<.001), so that the education level affects the errors in different forms of dyslexia, and specifically the errors in LD, with the children in 3rd grade to do most of them. With a change in the

class, children with VD and MD of dyslexia deal better in writing of text. In children with AD the number of errors significantly increases by the change in class. These children deal worse with the requirements of writing in 3rd grade. The same appears in children with LD, although the difference is smaller.

Table 2

Discussion

Acoustic, visual and linguistic errors in the writing of text represent categories of errors that are used to determine the forms of dyslexia. It is these errors to be identified as dyslexic. Therefore, they are analyzed in relation to gender and education level.

According to the definition of dyslexia, it is not the result of the absence of stimuli, sensory dysfunction and insufficient training and environmental factors, however, they can co-exist. Therefore, the symptoms of dyslexia (in this case errors when writing a text), are not a result of these causes. The education level and the quality of the training process are causal factors and dyslexic errors in writing of text are not their results. So, errors during writing of text to be identified as dyslexic must demonstrate that they are related to gender of children and are not related to level of education.

Analysis of different types of errors in relation with gender shows that there are significant differences between the sum of acoustic, visual and linguistic errors. Although, an analysis of AE, VE and LE in gender and grade groups shows that there are not significant differences between groups. The boys have greater values than the girls, which indicate a strongest pathology in writing. The same result is valid for the grade analysis. In grade groups we see that the values for AE and LE are too close, while the VE for 2nd grade is a little higher than the 3rd grade's. Combining gender with grade and grade with age we see that there are no significant differences in AE, VE and LE.

Analysis of different types of errors in relation with forms of dyslexia shows that there are significant differences in AE, VE and LE. An approximately equal count of the variance in AE and LE was explained by the types and forms of dyslexia. This suggests that these two groups of errors have similar effect on the differentiation of dyslexia in groups of dyslexia forms. Too interesting is the fact that VE are not associated with forms of dyslexia. This may be due to the very little count of children in our sample who are identified as VD. 2 children are identified as visual dyslectics with a dominant

subtype of visual dyslexia; none is identified with a clean form of visual dyslexia. This indicates that this form is quite rare in Greek children when they are examined by writing a text.

On the other side, the data analysis indicates that there is a relationship between acoustic and linguistic dyslexia and a relationship of visual subtypes and linguistic subtypes of dyslexia. It is evident that linguistic dyslexia it is possible to be related with the other two forms of dyslexia representing a mixed form, or specifically, a separate form of dyslexia which represents an attendant deficit in linguistic processing of written language. Exploring the dyslexia's subtypes we discover that the most types of dyslexia contain non-dominant linguistic or dominant linguistic errors. From the 13 subtypes of dyslexia, only 3 do not contain linguistic errors. This strongly suggests that linguistic dyslexia represents a mixed form of dyslexia. Although, there is evidence of the existence of a different mixed form, containing equal non-dominant errors of at least 2 different error categories. This indicates that linguistic dyslexia may be accepted as a separate form of dyslexia.

In conclusion we say that:

The errors in text writing of children of pre-school years can be categorized in groups of acoustic, visual and linguistic errors, according to their specific characteristics, which lead us to the categorization of the errors in acoustic, visual and linguistic errors, according to the disorder in the acoustic-cognitive, visual-spatial or linguistic process of incoming information.

Acoustic errors in writing of text are acoustic changes of letters, omission of letters, syllables or words, metathesis and antimetathesis of letters and syllables, errors in writing of palatial sounds and addition of letters, syllables or words. Visual errors in writing of text are visual changes of letters, repetition of letters, syllables or words, mirroring of letters, syllables or letter sequences, omission and repetitions of sequences. Linguistic errors in writing of text are errors in syntax and language usage, union and disunion of words, errors in use of punctuation marks and capital letters.

Developmental dyslexia can be categorized in forms of acoustic, visual and linguistic dyslexia, as well as a mixed form, according to the errors the children present in text writing. These errors are caused by disorder in acoustic-cognitive, visual-spatial or

linguistic process of incoming information and as a result the different types of dyslexia are due to specific causes.

Acoustic dyslexia is a type of dyslexia that is characterized by the appearance of acoustic changes of letters, omission of letters, syllables or words, metathesis and antimetathesis of letters and syllables, errors in writing of palatial sounds and addition of letters, syllables or words, in a percentage higher than 50% of the total number of errors in text writing, combined with visual changes of letters, repetition of letters, syllables or words, mirroring of letters, syllables or letter sequences, omission and repetitions of sequences, errors in syntax and language usage, union and disunion of words, errors in use of punctuation marks and capital letters.

Visual dyslexia is a type of dyslexia that is characterized by the appearance of visual changes of letters, repetition of letters, syllables or words, mirroring of letters, syllables or letter sequences, omission and repetitions of sequences in a percentage higher than 50% of the total number of errors in text writing, combined with acoustic changes of letters, omission of letters, syllables or words, metathesis and antimetathesis of letters and syllables, errors in writing of palatial sounds and addition of letters, syllables or words, errors in syntax and language usage, union and disunion of words, errors in use of punctuation marks and capital letters.

Linguistic dyslexia is a type of dyslexia that is characterized by errors in syntax and language usage, union and disunion of words, errors in use of punctuation marks and capital letters in a percentage higher than 50% of the total number of errors in text writing, combined with acoustic changes of letters, omission of letters, syllables or words, metathesis and antimetathesis of letters and syllables, errors in writing of palatial sounds and addition of letters, syllables or words, visual changes of letters, repetition of letters, syllables or words, mirroring of letters, syllables or letter sequences, omission and repetitions of sequences.

Mixed dyslexia is a type of dyslexia that is characterized by the appearance of acoustic changes of letters, omission of letters, syllables or words, metathesis and antimetathesis of letters and syllables, errors in writing of palatial sounds and addition of letters, syllables or words, visual changes of letters, repetition of letters, syllables or words, mirroring of letters, syllables or letter sequences, omission and repetitions of sequences,

errors in syntax and language usage, union and disunion of words, errors in use of punctuation marks and capital letters.

Further research is necessary in order to discover a possible relation of the errors in text writing with errors in text reading of children with developmental dyslexia. We would expect that the children present the same errors in both writing and reading, but this research cannot possibly provide such a conclusion.

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Παράρτημα

Table 1

Different types of errors in writing of text according to gender and education level

		Sum of different types of errors				
	N	Acoustic errors	Visual errors	Linguistic errors	χ^2	*p*
Boys	54	816	324	451	6.61	.038
Girls	54	432	172	301		
Totals	108	1248	496	752		
2nd grade	60	665	279	432	1.81	.405
3rd grade	60	644	242	390		
Totals	120	1299	521	822		

Table 2

Errors in different forms of dyslexia of text according to children's gender and grade

	N	Sum of errors in different types of dyslexia				χ^2	*p*
		Acoustic dyslexia	Visual dyslexia	Linguistic dyslexia	Mixed dyslexia		
Boys	54	436	5	776	374	58.22	.000
Girls	54	250	40	437	178		
Totals	108	686	45	1213	552		
2nd grade	60	283	40	614	429	242.20	.000
3rd grade	60	442	5	702	127		
Totals	120	725	45	1316	556