Morphological awareness of 11 year old Greek children with dyslexia: Investigation of an under-researched area

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Abstract

This study investigated morphological awareness in grade six (11 year old) Greek students with dyslexia to explore whether morphological difficulties pose an extra issue for children with dyslexia beyond their problems with phonology.

Method: Eighty-five students participated: 30 grade six students with dyslexia; 30 chronological age matched controls; 25 reading age controls.

Procedure: They completed four assessments: A reading ability test, phonological awareness subtests from the ATHENA battery, the Working Memory Battery for Children, and tasks of derivational morphology.

Results. Morphological awareness scores were statistically significantly different between children with dyslexia and the age matched group; they also performed lower than the reading age matched children on tests of morphological awareness (sentence completion; word identification with derived noun; nonword identification of derived pseudo-noun).

Conclusion: In this cohort morphological awareness tasks and working memory tasks (visuospatial sketch pad and central executive) best discriminated children with dyslexia at grade 6 from typically developing children.

Keywords: dyslexia, morphological awareness, phonological awareness, child language, Greek.

INTRODUCTION

This study concerns the basis of reading problems in 11 year old Greek children with dyslexia. Specifically it looks at whether morphological processing problems represent a significant hurdle for reading development. It has long been argued that phonological difficulties are a significant factor in reading delay. The possible impact of morphological issues has been less well examined. Greek provides a potential advantage in studying this, in that Greek has a transparent phonology (thus minimising possible problems in reading from phonology), but a complex morphology. The following sections provide the background for arguments around phonological and morphological factors in reading development and lay the ground for studying these in Greek.

1.1 **Metacognitive skills**

Metaphonological awareness concerns the "individual`s awareness of the sound structure or phonological structure of spoken words"(Gillon, 2017, p.37), that words consist of individual sounds and these are manipulated to create new or derived words (Moxam in press). Studies demonstrate that enhanced phonemic awareness in kindergarten is a strong predictor of reading acquisition in grades one and two and discriminates between children with dyslexia and reading age counterparts (Muter & Snowling 1998; Muter et al. 1997; Torgesen & Burgess, 1998; Wagner et al. 1993, 1997; Masterson, et al. 1995).

Metamorphological awareness concerns children's awareness of morphological word structure and their ability to reflect on it (Tsesmeli, & Seymour, 2006). Tyler & Nagy (1989) break it into relational, syntactic and distributional morphological awareness. Relational awareness refers to awareness of word structure and ability to analyse derived words in morphemes in tasks such as 'is the word farm in the word farmer?' (Carlisle, ·2000; Mahony, et al. 2000; Nagy et al. 2006). Syntactic morphological awareness concerns processing of derived words embedded in sentences. It is considered more eclectic and demanding compared to relational awareness as it constitutes the process through which derived words shift grammatical category (Tyler & Nagy, 1989). Completion of sentences with an inflected word, when the stem (initial word) is given, and selection of the proper word among four candidates are tasks used to evaluate syntactic morphological awareness e.g. 'This is a cat, these are two... (cats)'; 'Someone who sings is called a…(singer) (Carlisle, 2000;· Carlisle, & Fleming, 2003; Casalis, Cole & Sopo, 2004;· Flower & Liberman, 1995). Distributional morphological awareness is less studied and refers to subjects' ability to facilitate syntactic phonological and etymological constructions of language. Subjects reflect upon productive morphology in a language taking into account phonological, syntactic and etymological restrictions. This aspect of morphological awareness is assessed primarily by open type questions in which children are asked to confirm or reject words and pseudowords, e.g. 'Tablesome' is not a real word but the word "handsome" is'. Right or wrong? (Ku & Anderson, 2003;· McCutchen, Green &Abott, 2004).

1.2 Metacognitive skills and Dyslexia

Phonological Awareness

It has long been established in the literature that learning to read and write relies on metacognitive functions such as phonological and morphological awareness. Furthermore, working memory (the phonological loop) plays additional role. Deficits in any one of these skills result in a neurodevelopmental disorder dyslexia. Many studies have addressed metacognitive skill development and its relationship to spoken and written language and dyslexia (Snowling, et al, 1997; Stackhouse & Wells, 2001; Snowling& Melby-Lervag, 2017; Hulme & snowling, 2017; Gilon, 2017; Moxam in press) including Greek studies (Aidinis &

Nunes, 2001; Nikolopoulos et al. 2006; Caravolas et al, 2012; (Leveque et al. ,2017); Manolitsis et al 2017; Diamanti, et al. 2018 , Rothou & Panteliadou, 2019).

According to Snowling et all. (1997) "the development of decoding skills has traditionally been viewed as a stage-like process during which children's reading strategies change as a consequence of the acquisition of phonological awareness" (p31). Learning to read is determined primarily by a child's phonological representations and is therefore affected in children with dyslexia who have phonological deficits. The pioneering work of Snowling (1981) set the foundations for the phonological representation theory in reading. In her experiments she found that children with dyslexia, age nine to seventeen years, demonstrated poorer scores in contrast to reading age controls in decoding bi-syllabic nonwords and in non-word repetition (short term memory task). In a subsequent study, Wagner and colleagues (1987) used a battery of 22 test to establish the concepts of phonological representation (phonological analysis and synthesis, phonological short-term memory, isolated naming and serial naming of verbal material). They followed 222 children from kindergarten to second grade, and established a reciprocal connection of phonological processing abilities to children's reading ability. Furthermore, Gillon (2017) described in detail the importance of phonological awareness in decoding written material. In a recent article Hulme & Snowling (2017) claim that "Children with dyslexia find it hard to recognize printed words, have great difficulties 'sounding out' unfamiliar words, and often also read slowly" (p. 731) state that dyslexia represents the lower end of a continuous distribution of reading skills in the population. There is hereditary risk particularly for phonological processing and poor language development. Many children at risk for dyslexia display language difficulties in the preschool years. Furthermore, children with dyslexia often exhibit difficulties in reading comprehension. In conclusion, phonological awareness plays a major role in reading, particularly in decoding words at the earlier grades.

Morphological Awareness

Regarding morphological awareness, there has been controversy regarding the role of morphological awareness in reading and spelling development. Some claimed children from kindergarten to grade two rely mostly on phonological awareness (Henderson, 1985; Ehri& McCormick,1998) in reading and spelling, while others believed basic morphological awareness skills are present even at kindergarten age (Traiman & Cassar, 1996; Carlisle, 1995; Carlisle &Nomanhboy, 1993; Rubin, 1988; Walter, Wood &D`Zatko, 2009; Diamanti et al. 2017). More recent studies have shown that morphological awareness has a prominent role in vocabulary acquisition affecting through an indirect path literacy outcomes. (D'angelo Hipfner-Boucher & Chen, 1917; Law, Wouters, & Ghesquière, 2015). Using inflectional suffixes representing plurals in pseudowords (e.g. kug/kugs) and past tense (e.g. kug/kugged), Berko, (1958) showed children as young as four understand inflections (Rubin, 1988 and Treiman & Cassar,1996) tried to establish whether children at earlier stages of reading were less likely to omit consonants in two-morpheme words. They found children were more likely to omit the second consonant of single morpheme words containing clusters (e.g *blend/bled)* than in matched two morpheme words *rained/raid.* Carlisle, (1995) found first grade children better than kindergarten children on derivation and decomposition tasks and the performance of first graders on these tasks predicted performance on word analysis and reading comprehension in second grade. In a study by Casalis et al, 2004, they compared the performance of 33 children with dyslexia, to that of 33 children matched on reading-level and 33 on chronological age. They investigated also the influence of phonological impairments and the reader`s poor reading experience, with different tasks involving two studies. The results showed that dyslexic children scored lower on morphological awareness tasks. They claim that dyslexic children display a particular profile. They may have difficulty in morphological segmentation, probably due to their poor phonological skills, and that their knowledge about the relationship between base and derived forms in meaningful contexts corresponds to their reading level.

In a recent study by Leveque (Leveque et al. 2017), the relationship between morphological awareness and reading comprehension was examined in a sample of 221 English speaking typically developing Grade 3 girls (mean age 8years 10 months). They administered morphological awareness tasks, reading comprehension, word reading, reading and analysis of the meaning of morphologically complex words (morphological decoding and morphological analysis), vocabulary, phonological awareness, and non-verbal ability. Multivariate path analyses revealed evidence of two indirect relations and one direct relation between morphological awareness and reading comprehension. Morphological awareness contributed to morphological decoding, which then influenced word reading and finally reading comprehension. Morphological analysis, contributed to reading comprehension. Finally, in their direct path model, morphological awareness contributed to reading comprehension beyond all other variables.

Siegel et al (2008) examined the relationship of morphological awareness to reading and spelling skills in children with dyslexia, children who were typical readers and children who were English language learners. Their sample consisted of 1,238 students in Grade 6, of those 929 had English as first language (L1) and 309 were English language learners (ELL). Morphological awareness was significantly related to reading and spelling over and above the contribution of phonological awareness and oral language skills. No differences were reported between the ELL and the English L1 (native speaking) students.

Greek studies

The majority of studies in reading writing and dyslexia have been in English. The danger is that this introduces a bias into studies that reflect morphological and phonological properties similar to English. The Greek language shows some key differences to English, specifically that it is rich in morphology and orthographically transparent. This is one motivation for the importance of carrying out studies in Greek students. Some of the resent Greek studies are the following :

Diamanti etal, 2017, in a study of 104 Greek typically developing children, attending kindergarten, administered phonological and morphological awareness tasks, with follow-up assessments one year later. Their measures involved pseudoword reading, text reading fluency, text reading comprehension, and spelling. Reading accuracy for both words and pseudowords was predicted not only by phonological awareness, but also by morphological awareness. However, only phonological awareness predicted reading fluency at that age.

The influence of morphological awareness on reading comprehension and reading fluency was investigated in a longitudinal study by Manolotsis et al. 2017. They followed 215 typically developing children at kindergarten, grade 1, and grade 2 level. At kindergarten and grade 1 the children were tested with tasks of inflectional, derivational, and compounding morphology, letter knowledge, phonological awareness, rapid automatized naming (RAN), and general cognitive ability (vocabulary and non-verbal IQ). Results showed that morphological awareness accounted for 2 to 5% of reading comprehension as early as kindergarten and grade1 level, but not of reading fluency. At grade 2 morphological awareness affected reading comprehension and fluency as well.

Another study by Rothou & Panteliadou (2017) posed two questions. The first question was whether grade 3 Greek-speaking children with dyslexia exhibit deficits in noun-adjective inflections and verb inflections measured in the context of a sentence. The second question was whether morphological awareness, phonological awareness, and vocabulary knowledge could simultaneously distinguish children with dyslexia from age-matched typically developing readers. Word decoding, reading fluency, receptive vocabulary, phonological awareness and noun - adjective inflections were assessed. Results showed that grade 3 children with dyslexia have difficulties in pluralisation of real nouns and adjectives and tense and case transformations, thus confirming that morphological awareness skills are poorer in children with dyslexia even in languages with transparent orthography and rich morphology. In conclusion, it seems that morphological awareness plays considerable role in reading comprehension and is defective in dyslexia .

1.3 Working memory

As mentioned earlier working memory (Baddeley (2000) has been found to play a role in learning to read and write and that working memory deficits may lead to dyslexia. Working memory particularly the phonological loop is involved in reading decoding because the child has to keep in memory the sounds in synthesis and analysis of the syllable. Performance on phonological working memory has been found to be a better predictor than phonological awareness for kindergarten to grade three students' ability in English, mathematics, and science (Baddeley, 2000; 2003), whereas general short-term memory (STM) failed to differentiate the low and average students (Gathercole et al. 2004). According to Gathercole (Gathercole et al., 2004) working memory plays a considerable role in academic success across the school years and that the intellectual operations required in the curriculum for mathematics and science are constrained by the general capacity of working memory. Furthermore, tasks, assessing the central executive and the visuospatial sketchpad (Baddeley, 2000; 2003) discriminate children with reading and mathematical disability (Gathercole, et al. 2009; Alloway, 2009; Alloway, et al. 2009; Alloway etal. 2018), Alloway (Alloway, 2006) concluded severity of disability in reading and mathematics is strongly associated with performance of the central executive and is a better predictor than general I.Q. scores of future learning outcomes in children with severe learning difficulty.

1.4 The Present Study

The review of the literature shows that Phonological awareness has been studied extensively and its role in reading decoding and fluency is well established. It is not the same with morphological awareness. There are fewer studies than for phonological awareness, there is controversy regarding it`s development, results are not clear about its contribution to reading other than its role in reading comprehension and may be fluency. Most of the studies focus on earlier kindergarten to grade 2 levels, and research for higher grades is poor. The same is true for working memory, we know its role in reading decoding and in general academics but we know little about its contribution to morphological awareness. Furthermore, the interaction of phonological awareness, morphological awareness and working memory in children with dyslexia is under-researched internationally and, studies in these areas are underrepresented in the Greek language.

The aim of the present study was to investigate the morphological awareness skills in Greek Children age 11 years and how it may relate to phonological awareness and working memory.

We hypothesised:

H_0 Greek children with dyslexia will perform at the same level as the reading and chronological age matched control groups on morphological awareness tasks and working memory battery test for children.

H_1 Greek children 11 years old with dyslexia will perform poorer as those matched in reading age on all morphological awareness and the phonological loop tasks of the Working Memory Test Battery for children.

H2) Greek children 11 years old with dyslexia will perform the same as those matched in reading age on all tasks of the central executive tasks of the Working Memory Test Battery for children and poorer compared to reading age matched control group on morphological awareness task..

H3) Greek children 11 years old with dyslexia will perform better as those matched in reading age matched control group on all tasks of the visuospatial sketched pad tasks of the Working Memory Test Battery for children.

2. METHOD

Participants were 85 students (30 grade 6 children, mean age 11 years 7 months with dyslexia, 30 chronological age control students, and 25 grade 4 reading age control students (mean age 10 years 6 months). They were monolingual native speakers of Greek with no history of hearing or neurological problems. The groups came from three Primary Schools XXX (removed for blind reviewing) in XXXX, after obtaining ethical board permissions from the Department of Primary Education Supervision Board, and the parents.

Inclusion criteria for all three groups were: Nonverbal I.Q. >90 (-1 SD) as measured by the Test of Nonverbal Intelligence (TONI-III) (Brown, Sherbenou, Johnson, 1997),reading comprehension score >85 (-1 SD) for chronological age group, reading age control group and for children with dyslexia on the Reading Ability Test (Triga, 2001). The latter test tags vocabulary knowledge in a test of reading comprehension. The reading age control group was matched to children with dyslexia on raw scores.

Children with dyslexia were diagnosed as having the diagnostic criteria of dyslexia in the local Diagnostic and Support for educational Needs Centre, Authorised by the Greek Ministry of Education. At the time the study was conducted the discrepancy criteria WISC-III was used for the diagnosis of dyslexia. Given that the results of that test is “sensitive” are not given to the formal diagnostic form neither to schools nor to the parents. For the purpose of the current study in children who have already been diagnosed as having dyslexia further two criteria were applied. Student with dyslexia where having a performance on TONI-C ›,90(-1 SD) and performance on two phonological awareness tasks of the ATHENA Test at or below the 16th percentile (-1SD) (Paraskevopoulos *et al.*, 2001). Moreover, all group children participated in the study were monolingual Greek Speaking children.

Procedure

All subjects completed the following tests presented in a random order, with all testing conducted by the main author (XX) at the X XXX (removed for blind reviewing).

1) Four subtests of phonological sensitivity and phonological awareness from the ATHENA test (Paraskevopoulos, 2001):

a) "*phoneme blending"*, a 32-item task where subjects have to combine the orally presented phonemes, ranging from 4-7, to form a word e.g. /c/, /a/,/t/ (cat);

b) "*phoneme discrimination*", involving same/different identification of phoneme strings comprising a pair of non-words e.g. /kretokes/versus /krentokes/, same or different?;

c) *"grapheme discrimination",* a paper and pencil task in which a pair of non-words is presented in written form and subjects indicate where the words differ (if they do), e.g. μαδος/mados/ versus ναδος /nados/;

d) *"word completion"* where participants listen to a word missing an initial or intermediate phoneme and they have to say the correct form e.g. /aθaros/ for the word /kaθaros/ (clean, adjective).

2) The "Reading Ability Test" (Triga, 2001), a sentence completion test where students select the word which fits the meaning and the syntax of a sentence from four candidates. e.g. On hot days I really like to eat ...[ice-cream, icing, frost, peacock].

3) The Working Memory Test Battery for Children (WMTB-for children; adaptation and translation, Grammenou, 2011).

4) Reading and spelling ability were further tested with subtests constructed for the purpose of the present work.

i) Word and ii) non-word reading and spelling. Each test consisted of 92 real words and 92 plausible non-words for reading, with all possible combinations of consonant-vowel (CV), consonant cluster-vowel in the Greek Language (CCV, CCCV), vowel-consonant (VC) in stems before suffixes are added (Grammenou, 2010).This test was used to examine reading fluency and possible error types in spelling (Grammenou 2010 a, b). Errors were classified as 1) grammatical errors in the noun or verb suffixes, (real words) 2) orthographic processing errors in the word stems (real words) and 3) as phonological errors (real words and non-words). Test–retest reliability for scoring and performance on these reading tests, after a two months period was 0.80 (word list reading) and 0.83 (non-word list reading). Testing material is available from the first author upon request.

5) *Reading time* of the words was also included, as a predictor of reading ability among children with dyslexia according to the double deficit theory (Wolf, & Bowers, 1999).

6) Morphological awareness was evaluated in three tests.

i) *identification of derived nouns* in various grammatical cases in a paper and pencil test. Subjects decided whether the noun was a correctly derived noun form of the verb given in the 1st person singular of the present simple tense (e.g. I interrupt - interruption. Right or wrong). (διακόπτω, διακοπή, σωστό ή λάθος. Given that the Greek language is rich in morphology and most word categories are based on verbs (they are used to construct nouns and the nouns are used to construct adjectives or gerunds) this test was employed to shed light in the factors that might affect spelling of derived nouns.

ii) *identifying non-word items* (with noun suffixes in the nominative case, singular), resulting from the non-words (with verb suffixes)in the 1st person singular of the simple present tense. For example: for the word pairs /zoɣrafi′zo/ 'to paint' and /zoɣrafik′i/ 'painting' the non-words /loɣrafi′zo/ (verb suffix) and /loɣrafik′i/ (noun suffix) were constructed.

iii) *derivational noun morphology* in a sentence completion close test. Subjects used the verbs given in the first person singular present simple tense to formulate nouns in appropriate case and number to fit the meaning (the requested gender was inferred by the article given) e.g. ‘After losing the ball, ... was painted on his face’ [answer 'disappointment' from the given verb 'to disappoint']. There was a positive … at the invitation of the Association [answer response from the verb respond]. Υπήρξε θετική … στο κάλεσμα του συλλόγου και όλα τα μέλη ήταν παρόντα στη συνεδρίαση [απάντηση: ανταπόκριση από το ρήμα ανταποκρίνομαι].

Data Analysis Plan

Scores were derived from test results. Dependent variables were the (sub)test scores; reading groups acted as the independent variable. Data were tested for normality of distribution (Kolmogorov-Smirnov test; Shapiro-Wilks) and from these analyses conducted employing appropriate parametric (one-way ANOVA,) or nonparametric tests (Kruskal Wallis, Mann Whitney/Wilcoxon). Initial comparison examined if there was a statistically significant difference between groups on a given (sub)test. If there was, we conducted systematic post hoc analyses between pairs of groups (t tests for ANOVAs; Mann Whitney for Kruskal Wallis) to examine between which particular group(s) the difference(s) lay. Corrections were made for these multiple comparisons (Bonferroni/Tukey HSD for ANOVAs/t tests; adjusted p value for Kruskal Wallis/Mann Whitney). Two-tailed results are reported. Alpha was set at $P < 0.05$. Analyses were performed using SPSS 19.

3.0 RESULTS

The following section outlines the results for the different tests according to phonology, reading and spelling, working memory, and the key morphological subtests.

Phonological awareness

Sub-tests from the ATHENA test were compared to evaluate children's acquisition of phonemic awareness, their knowledge of grapheme–phoneme convention rules and their performance on decoding ability. Results (Kruskal Wallis; post hoc adjusted Mann Whitney tests) are summarised in tables 1 and 2.

Table 1-2 about here

Table 1: Group performance on the phoneme awareness tasks (subtests for the ATHENA Battery).

	Children with	Reading	Chronologicall

	dyslexia		age matched		y age matched	
	Mean	SD	Mean	SD	Mean	SD
Phoneme Blending	21.08	4.4	23	3.38	28.80	2.69
Phoneme Discrimination	22.41	4.55	22.21	2.43	28.14	2.6
Grapheme Discrimination	25.42	4.84	25.42	3.65	30.71	2.8
Word Completion	29.74	3.69	21.92	2.23	27.54	1.84

Table 2: Statistical comparisons between investigatory groups for subtests from the ATHENA Battery showing test statistics (Kruskal Wallis col 1; Mann Whitney pairwise tests) and significance level (p).

	Kruskal Wallis all groups	Reading age matched compared to children with dyslexia	Chronologically age matched children compared to Children with dyslexia	Chronologicall y age matched compared to reading age matched children

Phoneme Blending	45.27 p<0.001	1.56 p=0.118	6.6 p<0.001	4.8 p<0.001
Phoneme Discrimination	36.58 p<0.001	-0.78 p=0.44	5.2 p<0.001	5.37 p<0.001
Grapheme Discrimination	27.86 p<0.001	-2.44 p<0.05	3.3 p<0.001	5.24 p<0.001
Word Completion	45.53, p<0.001	1.44 p=0.150	6.04 p<0.001	5.2 p<0.001

The first column of results represents the *Kruskal* Wallis analysis of all groups (non-parametric equivalent to ANOVA), and the 2nd to 4th results columns represent each of the pairwise tests between the three groups.

The results show that children with dyslexia perform better than reading age matched control group in the grapheme discrimination tasks. Chronological age matched control group without dyslexia have significantly better phonological skills for reading than do those with dyslexia. The children with dyslexia overall are performing similarly to reading age control group, with the exception of grapheme discrimination.

Reading and spelling tasks

Results for spelling ability was tested by spelling to dictation of words and non-words. Errors were classified as 1) grammatical errors in the noun or verb suffixes, (real words) 2) as orthographic processing errors in the word stems (real words) and 3) as phonological errors (real words and non-words). Results are summarised in tables 3-4.

Table 3 about here

Table 3: Group performance on reading and spelling tasks

	Children with dyslexia		Chronologically age matched		Reading age matched	
	Mean	SD	Mean	SD	Mean	SD
Reading time words (in seconds)	103.59	39.21	71.79	25.63	87.29	24.38
Reading time nonwords (in seconds)	146.19	49.06	104.14	21.49	134.04	36.18
Real Word Phonetic errors	6.27	4.06	0.96	0.5	2.29	2.33
Nonword Phonetic errors	13.92	6.87	1.29	0.46	2.96	3.04
Word Orthographic Processing errors	16.43	5.7	1.96	1.14	5.4	4.4
Word Grammatical errors	8.70	5.61	1.29	0.81	2.29	1.78
Reading Ability Test (raw score)	14.25	7.2	21.21	5.27	14.08	5.21

Table 4: Statistical comparisons between investigatory groups for subtest for group comparisons on reading and spelling tasks, including error types. All groups = Kruskal Wallis; pairwise = Mann Whitney.

	All groups	Reading age matched compared to children with dyslexia	Chronologically age matched children compared to Children with dyslexia	Chronologically age matched compared to reading age matched children
Reading time real words (in seconds)	16.03 p<0.01	-1.4 p=0.17	-4 p‹0.05	-2.31 p‹0.05
Reading time non words (in seconds)	21.46 p<0.001	-0.79 p=0.43	-4.49 p‹0.001	-3. 3 p‹0.001
Real Word Phonetic errors	49.06 p<0.001	-4.5 p<0.001	-6.73 p<0.001	-1.78 p=0.075
Nonword Phonetic errors	63.4 p<0.001	-5.6 p<0.001	-7.45 p<0.01	-1.14 p=0.16
Word Orthographic Processing errors	61.78 p<0.001	-5.23 p‹0.001	-7.5 p<0.001	-1.82 p=0.068
Word Grammatical errors	54.78 p<0.001	-4.94 p<0.001	-7.06 p>0.001	-1.69 p=0.09

Reading Ability Test (raw score)	23.67 p<0.001	0.06 p=0.950	4.46 p‹0.001	4 p<0.001

The first column of results represents the Kruskal Wallis analysis of all groups in the reading and spelling tasks of words and non-words and the Reading Ability Test (non-parametric equivalent to ANOVA), and the 2^{nd} to 4^{th} results columns represents each of the pairwise tests between the three groups.

Kruskal Wallis testing showed a statistically significant difference amongst the three groups. Pairwise adjusted comparisons between subgroups revealed that these differences lay not just in poorer performance of the children with dyslexia compared to their chronological age matched control group, but also compared to reading age matched group. The null hypotheses H0 is thereby rejected. In particular also, the results show that the children with dyslexia commit not just significantly more sound/grapheme-based errors, but have a significantly higher morphological deficit (word grammatical and orthographic processing errors) compared to both control groups. The overall difficulty of dyslexic children also comes through in their reading time. Although the total words in error is not robust across groups, when we observe reading time, then the problems of the children with dyslexia emerge as they scored similar to reading age matched group.

Working memory

Results for the working memory subtests appear in tables 5-6.

Table 5-6 about here

Table 5: Group's performance on the Working Memory Test Battery-C

	Children with dyslexia		Grade 6 chronological age matched		Grade 4 reading age matched	
	Mean	SD	Mean	SD	Mean	SD
Forward digit recall	26.54	6.18	34.21	3.7	28.96	3.42
Word list recall	19.75	3.43	27.71	4.1	24.88	2.61
Non wordlist recall	26.54	6.18	23.32	3.23	19.75	3.24
Block recall	26.17	3.59	31.79	4.08	26.54	6.18
Mazes memory	27.46	3.85	30.14	3.31	23.58	4.26
Backward digit recall	23.14	3.57	24.13	3.18	26.86	4.54
Counting recall	16.03	4.08	15.96	4.33	21.93	3.07

Table 6: Statistical comparisons between investigatory groups for subtest comparisons between groups on executive/memory tasks

	All groups	Reading age matched compared to children with dyslexia	Chronologically age matched children compared to Children with dyslexia	Chronologically age matched compared to reading age matched children
Forward digit recall	36.65 p<0.001	1.35 p=1.176	5.94 p<0.001	4.068 p<0.001
Wordlist recall	18.13 p<0.001	1.31 p=1.19	4.23 p‹0.001	2.58 p<0.05
Nonword list recall	36.84 p<0.001	2.18 p<0.001	6.06 p‹0.001	3.4 p<0.05
Block recall	24.20 p<0.001	0.94 p=0.345	4.78 p‹0.05	3.44, p<0.001
Mazes memory	28.23 p<0.001	-3.22 p<0.05	2.52 p<0.05	5.31 p<0.001
Backward digit recall	30.32 p<0.001	0.177 p=0.86	5.09 p‹0.001	4.42 p‹0.01

Counting recall	10.92 $p<0.05$	1.02 $p=0.38$	3.28 p‹0.05	2.0 p‹0.05

The first column of results represents the Kruskal Wallis analysis of all groups (non-parametric equivalent to ANOVA), and the 2nd to 4th results columns represents each of the pairwise tests between the three groups in the WMTB-C Test.

Results from these subtests demonstrated that pupils with dyslexia score significantly poorer than their age counterparts in all measures (null hypothesis H0 rejected). They also score significantly poorer than pupils matched for reading age when it comes to nonword list recall (H1 hypothesis confirmed). The pattern of results is reversed on the mazes memory recall task in which children with dyslexia outperformed reading age matched group (H3 hypothesis confirmed). The statistical comparison between reading age control group and children with dyslexia has shown also that the two groups are not differentiated in the forward and backward digit recall task, in word list recall task, in the counting recall task and in the block recall task (H2 hypothesis confirmed).

Derivational noun morphology

Tables 6-7 portray the sentence completion test results. Internal consistency in total scores for the sentence completion task was satisfactory for the total sample α=0.87, M. =136.33, S.D=19.40. The highest score of alpha coefficient was observed in students with dyslexia (α=0.86, M.=123.7, S.D=21), followed by chronological age matched group (α=0.79, M.=149.37, S.D=10.79) and reading age matched group (α=0.712, M.=140.80, S.D=12.27).

Tables 6-7 about here

TABLE 6-7: Statistical analysis for the sentence completion task

	Children with dyslexia		Chronological age matched		Reading age matched	
	Mean	SD	Mean	SD	Mean	SD
Correct type of derived nouns	10.74	7.71	24	7.0	18.08	7.32
Inability to produce derived nouns	8.88	4.9	2.5	2.6	3.92	3.9
Phonological errors	2.21	3.62	0.1	0.4	0.38	0.95
Orthographic processing errors	5.56	5.58	3.4	2.3	5.40	3.05
Punctuation errors	5.38	5.58	1.9	4.3	4.2	5.90

Table 7: Comparisons between groups for scores on the sentence completion test. All groups = Kruskal Wallis; adjusted pairwise = Mann Whitney.

	All groups	Reading age matched compared to children with dyslexia	Chronologically age matched children compared to Children with dyslexia	Chronologically age matched compared to reading age matched children
Correct type of derived nouns	16.07 $p<0.01$	43.96 $p < 0.001$	23.78 $p <0.01$	20.17 $p<0.01$
Inability to produce derived nouns	29.02 $p <0.01$	37.0 $p <0.05$	28.06 $p <0.01$	28.0 $p <0.01$
Phonological errors	15.07 $p <0.01$	20.04 $p <0.01$	15.32 $p <0.01$	4.72 $p<0.05$
Orthographic processing errors	7.31 $p<0.01$	17.79 $p <0.01$	18.16 $p <0.01$	3.73 $p = 0.95$
Punctuation errors	5.68 $p<0.001$	27.80 $p <0.01$	14.61 $p <0.01$	13.19 $p = 0.75$

The first column of results represents the Kruskal Wallis analysis of all groups and the 2nd to 4th results columns represents each of the pairwise tests between the three groups in the sentence completion test.

Performance on these subtests shows that whilst typically developing 6th grade pupils and 4th grade children achieve similarly on orthographic processing and punctuation, therefore suggesting acquisition of these skills in Greek is complete by 4th grade, the 4th and 6th grade students still differ significantly on phonology and derivation of nouns. The indication is that s children with dyslexia have not achieved to fully develop spelling of derived nouns at least up until 6th grade. The severity of the problems faced by the children with dyslexia is underlined by the fact that they performed significantly below even their reading age matched associates on all these tests, thereby confirming the alternative hypothesis and underlining that in these Greek pupils with dyslexia their difficulties entail not just phonology but also morphology.

Factors in noun verb derivation

Forward regression analyses were conducted for each group to shed light on factors, and their relative predictive value, that might link to their ability to formulate derived nouns from verbs in the written form. Predictors entered covered all other test results, including non-verbal IQ, memory, central executive tasks and age.

Table 8: Multiple Regrassion Analysis for sentence completion by children with dyslexia.

	Model 1			Model 2			Model 3		
	B	SEB	β	B	SEB	β	B	**SEB**	β
Grapheme Discrimination	3.14	1.00	0.53	2.68	0.95	0.45	4.26	1.14	0.72
Word Completion				2.38	1.04	0.37	2.86	0.99	0.44
Block Recall Span							-14.45	6.57	-0.44
R 2		0.28			0.41			0.51	
F for change in R		9.84			5.2			4.82	

Table 9: Multiple Regression Analysis for sentence completion by chronological age control group

	Model 1			Model 2		
	B	SEB	β	B	SEB	β
Reading Ability Test	0.85	0.37	0.42	0.90	0.34	0.45
Phonological Loop				1.5	0.67	0.39
R^2		0.18			0.33	
F for change in R		5.26			5.2	

Table 10: Multiple Regression Analysis for sentence completion by reading age control group

	Model 1			Model 2		
	B	SEB	β	B	SEB	β
Block Recall Row Score	2.33	0.86	0.55	2.58	0.64	0.61
MazesMemory Span				-23.85	6.05	-0.59

R^2	0.31	0.65
F for change in R	7.3	15.53

The results clearly demonstrates that children's' with dyslexia performance on morphological awareness is explained 51% by one phonological representation test (word completion 28.2%) grapheme-phoneme correspondence (grapheme discrimination 12.8%) as well as by one visuospatial sketch pad test (block recall span 10.3%). Moreover, 64.5% of reading age control group's performance is explained by block recall (31%) and mazes memory span (34.5%). Performance of chronological age group is explained 33.1% by the Reading Ability test (18%) and the phonological loop tests (digit recall row score, nonwords recall row score and words recall row score, 15.1%).

Word identification

Participants were asked to identify the correct or incorrect derived noun forms for given verbs. This task is considered more demanding in terms of cognitive control as children must analyse the initial verb in the stem morpheme and the verb suffix and combine the former with the appropriate noun suffix available from the mental lexicon. Results are presented in table8.

Table 11 about here

Table 11. Performance on the Word and Non-word Identification task

	Word identification (n32)		Non-word identification (n32)	
	Mean	SD	Mean	SD
6th grade	26.5	3.90	27.7	3.79
4th grade	23.2	4.94	23.92	4.90
Dyslexic children	19.23	4.86	19.23	4.86

There was a statistically significant difference between groups for real word identification (one-way ANOVA ($F(2,89) = 9.32$, p = <0.01). Tukey HSD post hoc tests revealed there was a statistically significant difference between 6th grade students over those with dyslexia (p=<0.001), but no other significant differences. For non-word identification there was a statistically significant difference between groups (one-way ANOVA (F(2,89) =27.34, p = <0.01). Tukey HSD post hoc tests revealed a statistically significant difference between 6th and 4th grade students over students with dyslexia (p=<0.01 for both comparisons). There was also a significant difference between the two groups of typically developing children (p=0.01). There were no significant differences within groups between performance on real versus non-words.

Similar to the sentence completion task, six sets of multiple regressions for the three comparison groups were performed for word and nonword identification.

The results of the regression analyses based on the word identification test as outcome demonstrated that children's with dyslexia performance is accounted by phonemic errors in words (49.8%) by the central executive tasks (11.8%) by grapheme discrimination (8.1%) and by the visuospatial sketchpad (8.7%).The results of the regression analysis based on the word identification test as outcome demonstrated that the reading age control group's performance is accounted by age (31.1%), by the central executive (11,8%), by the phonological loop (3%), and by phonological awareness tests (7%). The results of the regression analysis based on the word identification test as outcome demonstrated that chronological age control group's performance is accounted by age (26.2%).

A similar procedure was followed for the nonword identification test. The results of the regression analysis based on the nonword identification test as outcome demonstrated that children's with dyslexia performance is accounted for by age (18.7%), by nonverbal I.Q. (26.3%), as measured by Toni_C, (Brown, Sherbenou, Johnson, 1997) by phoneme discrimination and by counting recall row score (32.1%).

The results of the regression analysis based on the nonword identification test as outcome demonstrated that the chronological age control group's performance is accounted for by nonword list recall raw score(28,7%), by mazes memory span (12.9%), by backward digit raw score (10.6%) by backward digit span, (9.3%) and by block recall raw score, (7.3%).

For the reading age control group the regression analysis with outcome of nonword identification performance is accounted for best by grapheme discrimination test, (7.68%).

Table 12: Multiple Regression Analysis for word identification by dyslexic group

	Model 1			Model 2			Model 3			Model 4		
	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β
Words phonemic errors	1.26	0.23	0.71	1.26	0.23	0.71	0.98	0.24	0.54	0.,84	0.21	0.47
Central exectutive				-0.35	0,130	-0.34	-0.33	0.12	-0.32	-0.39	,0.11	-0.38
Grapheme discrimination							-,588	0.24	-0.33	-0.75	0.21	-0.425
Visuospatial sketchpad										0.38	0.13	0.32
R^2	0.5			0.61			0.7			0.78		
F for change in R	24.78			7.08			6.04			8.72		

	Model 1			Model 2			Model 3			Model 4		
	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β
Age	0.55	0.19	0.56	0.61	0.18	0.62	o.61	0.189	0.63	0.68	0.19	0.69
Central exectutive				0.36	0.19	0.35	0.37	0.20	0.37	0.4	203	0.06
Phonological loop							-0.05	0.17	-0.05	-0.10	0.17	0.12
Phonological awareness										-0.05	0.04	-0.28
R^2	0.5			0.61			0.69			0.78		

F for change in R	8.12	6.4	4.06	3.78

Table 14: Multiple Regression Analysis for word identification by reading age matched group

Table 15: Multiple Regression Analysis for word identification by chronological age matched

	Model 1		
	B	SEB	β
Age	-0.5	0.17	-0.51
R^2	0.26		
F for change in R	8.5		

Table 16: Multiple Regression Analysis for nonword identification by children with dyslexia

	Model 1			Model 2			Model 3		
	B	SEB	β	B	SEB	β	B	SEB	β
central exectutive	0.23	0.05	0.5	0.15	0.06	0.33	0.15	0.06	0.32
Phonological loop				0.12	0.05	0.28	0.12	0.05	0.28
Visuospatial sketch pad							0.012	0.052	0.027
R^2		3.48			3.38			3.4	
F for change in R		25.04			5.23			0.06	

Table 17: Multiple Regression Analysis for nonword identification by chronological age control group

	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB	β
Nonword list recall row score	0.52	0.17	0.54	0.53	0.16	0.54	0.59	0.15	0.6	0.59	0.14	0.6	0.56	0.13	0.57
Mazes memory Span				-1.87	0.83	-0.36	0.56	0.13	0.57	-2	0.72	-0.38	-1.44	0.71	-0.28
Backwsrd digit row score							-0.302	0.14	-0.34	-0.68	0.21	-0.75	-0.7	0.19	-0.78
										2.5	1.11	0.52	3.89	1.06	0.75
Backward digit_span													0.21	0.1	0.30

block_recall _row					
				0.61	0.69
	0.29	0.42	0.52		
R^2				5.1	
	9.66	5.07	4.85		4.7
F for change in R					

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Discussion

The aim of the present study was to explore the performance of Greek speaking children with dyslexia and typically developing children on morphological awareness tasks, and to investigate the factors that influence their performance.

The prediction that the children with dyslexia would perform significantly more poorly than chronological age matched students is born out, in that the majority of tests involving sound/grapheme manipulation and processing attained levels at or better children two years younger. The null hypothesis, that children with dyslexia will function at the same level as their reading age peers in morphological awareness tasks, was not confirmed. In fact the children`s with dyslexia performance was poorer on the majority of tasks. There were statistically significant differences in the performance of all three groups in morphological awareness tasks, which shows that morphological awareness tasks are difficult for and thereby maybe more discriminative in identifying children with dyslexia at higher grades. Results of the present study clearly demonstrated that children with dyslexia experienced restrictions in formulating the proper derived noun from the initial verbs, as well as formulating the proper derived noun even when the stem was given. The outcomes of the present study shed light on a debated issue of phonological representation theory, the contribution of morphological awareness over phonological awareness and reading comprehension in reading and spelling. As Pennington, (2006, p394) points out despite the strength of the phonological deficit hypothesis, it seems that phonological difficulties are neither necessary nor sufficient to account for dyslexia. Furthermore, for children with dyslexia orthographic representation of affixes was inferior compared to the reading age control group with the same phonological awareness. The case of Greek children with dyslexia seems to meet the aforementioned hypothesis due to primarily rich morphological level which poses heavy demand on visuospatial sketchpad and the function of the central executive. It worth mentioning again that the central executive functioning as measured by the counting recall and backward digit recall has been develop to an equivalent degree as those reading age matched group. Analysis of derived words in stems and suffixes poses heavy demands on the central executive and the orthographic representation of different morphemes presupposes processing on visuospatial sketchpad. Three hypothesis is verified in the present study suggesting that a new approach in the Greek language curriculum may be beneficial to children with dyslexia. A rich morphological language must take into account the limitations posed by the capacities of the central executive and visuospatial sketchpad. We propose that teaching stem and affixes must be organised in such a manner to highlight the similarities and differences in the meaning of morphemes and to contrasted them to their orthographic representation. This will assist children with dyslexia to organise a "mental orthographic lexicon" with the common morphemes used in the Greek language.

Results reflect previous studies. Casalis, (2004) examined the performance of children with dyslexia on a series of morphological awareness tasks and compared it with the performance of children matched on reading-level and chronological age. In all the tasks, the children with dyslexia performed below the chronological age control group, suggesting that morphological awareness cannot be developed entirely independently of reading experience and/or phonological skills. Comparisons with the reading-age control group indicated that, while the children with dyslexia were poorer on the morphemic segmentation tasks, they performed normally for their reading level in the sentence completion tasks. Likewise Carlisle (1987) found that children with dyslexia do not appreciate the shared morphemes between derived and base words and produced a greater number of spelling errors. In Carlisle's study children with dyslexia kept the phonotactic structure of the produced words in the same level as reading age controls contrary to the results of the present study in which children with dyslexia produced almost six times more phonologically implausible errors. Similarly, Tsesmeli and Seymour (2006) noticed that adolescent dyslexic children produced more phonologically implausible errors in spelling derived words than reading age and chronological age control groups, despite the fact that the magnitude of this type of errors was the same as in chronological age and reading age control groups and vocabulary was controlled.

A recent study in Greek by Diamanti and colleagues, (2018) established contrary findings to the present study. They found no statistically significant differences between children with dyslexia and reading age counterparts on a homonym stem choice task and on a spelling of suffixes task, suggesting that morphological awareness is developed hand in hand with reading ability. The differences in outcomes between the aforementioned study and the present study may be attributed to the diagnostic criteria for dyslexia. For the present study a reading comprehension test was used, not a sight word reading test (see also Deacon et al, 2006). Moreover, children with dyslexia in the present study had inferior phonological awareness abilities in three tasks which reflected scores of the reading age counterparts. This strongly suggests that children with dyslexia are affected by a second major deficit associated with morphological awareness additional to their primary phonological deficit.

Regarding which factors influenced the dyslexic children`s performance, results showed that, at this age, difficulties are not in decoding or reading of words, but mostly in spelling. This is expected because the grapheme/phoneme correspondence in Greek is transparent; also the ‘teaching literacy method’ followed in Greek schools combines “whole word” and “phonemic" approaches (how does a letter sound). Thus, children are familiar with the “sound like task” which they have practised not only in first grade but every time they encounter an unfamiliar word. The second factor that seemed to contribute to children’s with dyslexia satisfactory performance of reading words and non-words was their phonological awareness skills as performance on the ATHENA test showed. As Elbro (1998) and Cao and colleagues (2006) point out, students with dyslexia are capable of accessing phonologically distinct words but they fail to manipulate sublexical units.

Children with dyslexia made more phonological, grammatical, and orthographic errors, than their reading age controls in the spelling task. The results from the phoneme awareness and reading and spelling tasks suggest that acquisition of literacy for children with dyslexia fits well with the model proposed by Stackhouse & Wells (2001). Phoneme and orthographic representations of high frequency words with sparse phonological and orthographic neighbours are intact, but orthographic representation of non-words are affected to a greater degree as results of the “grapheme discrimination” and “non-word spelling” suggests. It is interesting that children with dyslexia showed superior performance in “grapheme discrimination” of the phonemic awareness task as well as in the “mazes memory recall” of the working memory battery task. This mast be interpreted with regard to the high phoneme -grapheme correspondence of the Greek language. From first grade onwards Greek children learn to link letter names to phonemes they represent. The grapheme discrimination task tags letter discrimination, which children mast resolve associating either by assigning letter name or phoneme to the pair of graphemes contrasted. So, letter names and phonemes are always stable in the Greek language and children with dyslexia are in advance compared to reading age matched control group due to reading experience but not so good compared to chronological age matched control group due to a speculative phonological representation deficit. The phonological representation deficit is evidenced by the poorer performance of the nonword recall task. In that account they try to resolve the orthographic representation of Greek language words by using visual aids which is based mostly on the visuospatial sketch pad. Speculatively, this may indicate a superiority in the usage of the visuospatial sketch pad of working memory in children with dyslexia. In order to shed light on the factors determining the group’s orthographic representation of derived words we used stepwise regressions analyses. Performance of students with dyslexia was linked to block and maze recall tasks that tag kinaesthetic abilities and memory. Presumably the children have to search through the words to find the common stem and to isolate the affixes in order to compare it with the information stored in long term memory, so the different subsystems of memory and in particular the sketchpad play a definite role. The superior performance of children with dyslexia in mazes memory recall and their similar performance of the aforementioned group compared to reading age matched control group shows that this could be so. This finding is compatible with Ramus's (2003) argument according to which dyslexia is also accompanied by general sensorimotor deficiencies. Berninger et al, (2006) in a study of 122 children with dyslexia and their 200 biological parents found that both children and parents were most severely impaired in memory (phonological word storing, the phonological loop, and the executive factor involving phonology. The executive factor in children contributed uniquely to oral reading but did not contribute uniquely to reading comprehension or written expression. It is worth mentioning that this study conducted in an opaque language.

Conclusion

Overall, results of the present study demonstrated that morphological awareness in Greek children with dyslexia poses extra difficulties in processing written words. Taking into account that a great number of words in children's text-books are derived words a new educational approach should be developed in teaching literacy. The grammatical rules of inflected words are introduced in the school curriculum as early as first grade. A similar approach should be followed for derived words with grammatical rules of generative grammar to be explicitly taught from first through to at least sixth grade in children's lessons of modern Greek language. An organisation of derived words of the same routes and emphasising the common route would be an excellent example of enhancing morphological awareness and words representations on the mental lexicon e.g. words like οικεία, /ik΄ia/, (familiar), κατοικία, /katik΄ia/, (residence), παροικία, /parik΄ia/ (community) οικογένεια /ikoγ΄enia/ (family) should be taught as "family" words. Computer programs, and computer work at home with hierarchically composed (from simple to harder) exercises of morphological awareness will further enhance the children`s reading and spelling. Of course, this, as well as other educational approaches, should be tested in extensive experimental studies.

What new does this study offer to international bibliography

There are very few if any studies on morphological awareness at higher than grade 4 grades.

In the present study, impairment of morphological awareness at 11 years of age in children with dyslexia seems to be an important factor affecting their spelling and academic skills

Remediation work on morphological awareness exercises should be included formally in the school curriculum.

Recommendations for future research

The morphological awareness skills of 11 year old children (Grade 6 in Greece) with dyslexia should be compared with control groups from grades 2,3,4, and 5 to see whether the children at 11 yrs function like the children of any one of the grades or do they develop morphological awareness abilities differently. It would be of scientific interest to replicate a similar research in other transparent languages such as German, in which reading rate also differentiated children which dyslexia from typical developing children.

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