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THE CONTRIBUTION OF SHORT-TERM MEMORY, WORKING MEMORY AND DEMOGRAPHIC CHARACTERISTICS TO THE LINGUISTIC ACHIEVEMENT OF GREEK MIDDLE SCHOOL-AGE CHILDREN: IMPLICATIONS FOR NATIVE LANGUAGE DEVELOPMENT

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Abstract:
The present study delved into the involvement of Greek-speaking middle primary school children's mnemonic recourses and demographic features in their performance in language tests. One hundred and seventy-six students aged 8.50-12.05 (mean age = 10.11 years) participated. The native language of the sample differed from English, in which most investigations have been conducted. Children's verbal short-term memory (STM) and working memory (WM) capacity were assessed with a simple verbal retention measure (straight digit recall) and a task requiring parallel storage and processing of verbal information (backward digit recall), respectively. Pupils' vocabulary knowledge was estimated through an assignment of expressive vocabulary. Children were also administered a reading fluency and a reading comprehension task. Pearson's *r* and Spearman's *rho* correlation coefficients showed that students' verbal STM and WM significantly correlated with their reading fluency and text comprehension, accordingly. In addition, by employing simple linear regression analysis, increase in participants' age was found to predict their extended reading fluency, while one-way Analysis of Variance (ANOVA) of independent samples revealed that vocabulary knowledge varied, being subject to pupils' school grade. Lastly, independent samples *t*-test demonstrated no substantial difference in reading fluency between the two genders of children. Current

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findings are discussed in relation to participants' age growth, their cumulating linguistic experience and the historical properties of the Greek language, indicating the need for further research that takes into account the unique and multifaceted nature of readers' profile and outlining a few connotations for literacy instruction.

Keywords: verbal short-term memory (STM), verbal working memory (WM), demographical attributes, linguistic performance/attainment, language tests, reading fluency, reading comprehension, vocabulary knowledge, language development, middle school-age children

1. Introduction

Students acquire language successfully when they attain an array of prerequisites, which relate to reader's abilities (e.g., fluency, decoding, prior knowledge, vocabulary knowledge, metacognition), as well as to the text's genre and content (Archer, Gleason, & Vachon, 2003; Fuchs, Fuchs, Hosp, & Jenkins, 2001; Mastropieri & Scruggs, 2005; Speece & Ritchey, 2005). In other words, language acquisition refers to the combination of knowledge-based and text-oriented structures and is the product of a systematic reading process that implements basic (e.g., fluency) and higher order (e.g., metacognitive strategy usage) reading skills (Padeliadu & Antoniou, 2014).

1.1. Short-term Memory and Working Memory: Conceptual Clarifications

Language development is considered to be inextricably linked to children's cognitive development (Karousou, 2015), as it pertains to specific cognitive factors, such as mnemonic capacity (Boyle, Lindell, & Kidd, 2013). In more detail, research suggests that short-term memory (STM) or working memory (WM), that is, the cognitive mechanism accountable for the adeptness of individuals to retain and manipulate information in mind for a short period of time (Baddeley, 2007a; Roussos, 2011), constitutes a key part of any learning course (Alloway, Elliott, & Place, 2010; Gathercole, Lamont, & Alloway, 2006; Martinussen & Major, 2011; Redick & Engle, 2006).

The term WM is often used interchangeably with STM, although the former covers more the whole theoretical framework of structures and procedures appointed for temporarily storing and managing information, of which the latter is just one division (Bablekou, 2009; Cowan et al., 2011). Mostly, the WM construct has been visualized as a multi-component system amenable for controlling attention and inhibiting bewildering information, concomitantly comprising a limited capacity central executive department that interacts with subsystems specialized in passive storage of verbal information (phonological loop component) or visuo-spatial information (visuo-spatial sketchpad component; Baddeley, 2007b; Cowan, 2005; Miyake et al., 2000; Pascual-Leone & Johnson, 2011).

1.2. The Influence of Memory Skills on Children's Language Performance: International and Greek Perspectives

A large body of research has addressed decoding and fluency in reading as core elements of reading comprehension across a number of languages and school grades (Ghelani, Sidhu, Jain, & Tannock, 2004). As reported in many studies with typically developing (TD) English-speaking young children, WM supports not only the acquisition of vocabulary, reading and spelling/writing (Gathercole, 2006; Gathercole, Alloway, Willis, & Adams, 2006; Gathercole & Pickering, 2000), but also the execution of upper level processing functions, like those required during text comprehension (Cain, Oakhill, & Bryant, 2004). In this manner, WM seems to be tied in with students' performance in their language tests (Alloway et al., 2005; Dehn, 2008; Kane & Engle, 2002; Nation, Cocksey, Taylor, & Bishop, 2010).

Similar are the findings of studies in the Greek language, that differs significantly from English as regards its writing system and its mechanism of reading acquisition (Chrysochoou & Bablekou, 2011; Chrysochoou, Bablekou, Masoura, & Tsigilis, 2013a; Chrysochoou, Bablekou, & Tsigilis, 2010; Georgiou, Parrila, & Papadopoulos, 2008; Maridaki-Kassotaki, 2002). Greek is a phonologically shallow, syllable-timed language that is mainly characterized by transparent orthography, wherein correspondence between graphemes and phonemes is direct, stable and premised on phonological rules, and its syllables are easy to discriminate (Seymour, Aro, & Erskine, 2003); hence, reading in Greek is smoothly achieved through a phonetic path (Georgiou, Protopapas, Papadopoulos, Skaloumbakas, & Parrila, 2010; Martin, Claydon, Morton, Binns, & Pratt, 2003) and the major instructional emphasis turns toward unlocking the meaning of written texts (Padeliadu & Antoniou, 2014).

However, data on the relationship of WM with reading in Greek-speaking children at an advanced stage of reading development is limited. Such an investigation would be of particular interest, since grapheme to phoneme matching in Greek is not always predictable due to the historical nature of its spelling system. Likewise, the Greek nominal system is defined by four grammatical cases and three genders (masculine – feminine – neuter), whereas the verbal system is even more multiplex, marking person, number, tense, aspect and voice features on morphological suffixes. Moreover, Greek has various derivational affixes susceptive of word-formation and category-formation processes. It is also demarcated by an averagely large amount of multi-syllabic compound words (Goswami, 2013; Porpodas, 2002).

Furthermore, according to studies with English-speaking participants after their seventh year of age, readers' consolidated knowledge about language (e.g., richness of their vocabulary) begins to play a more important role than WM to farther development of reading fluency and comprehension, of vocabulary acquisition (Alloway, Gathercole, Willis, & Adams, 2004; Gathercole, 2006; Walley, Metsala, & Garlock, 2003) and to the procurement of a second/foreign language (Gathercole & Masoura, 2005). By fifth grade of elementary school, an ample volume of novel words is introduced to students, and therefore decoding becomes an arduous task (Archer et al., 2003); reading experience is poignantly significant for the creation of high quality lexical representations (Perfetti & Hart, 2002).

1.3. Statement of the Research Problem

It has been proposed that, over age lapse, children depend less on short-lived traces (i.e., phonological storage) and rely more on permanent phonological and lexical records (i.e., long-term memory [LTM] system). As vocabulary knowledge increases, word representations become more segmental, fine-grained and phoneme awareness expands; this in turn results in superior speech perception and easier lexical access, abetting further language acquisition (Walley, Metsala, & Garlock, 2003).

This gradual detachment from WM could be observed earlier in the Greek language, by cause of its innate orthographic consistency (Goswami, 2013). Although WM measures are believed to be relatively free of socio-economic influences, peculiarities unique in each language (e.g., articulatory duration of words) do affect performance on memory tasks (Engel de Abreu, Santos, & Gathercole, 2008), especially if we are cognizant of the fact that Greek diverges considerably from English, where most empirical evidence derives from.

Indeed, in the upper elementary grades, students' reading comprehension is moderated by their vocabulary skills (Protopapas, Sideridis, Mouzaki, & Simos, 2007). Already at the age of 9, Greek-speaking children's reading fluency does not appear to disturb their textual comprehension (Chrysochoou et al., 2011; Papadopoulos, Georgiou, & Kendeou, 2009), whereas the contribution of measurements of WM in predicting oral apperception skills seems to decline in strength by children's age at 5.5, 7.5 and 9.5 years (Chrysochoou & Bablekou, 2008, 2011). In a similar vein, Greek 10-year-old students' language has been identified as the most important predictive indicator of their linguistic skills, compared to their non-verbal fluid intelligence and their WM (Chrysochoou, Masoura, & Alloway, 2013b). At the same time, the Greek educational system, which emphasizes established knowledge (Didaskalou, 2002), might favor its use more than the English one.

Commensurate to another viewpoint, the feminization of the school environment as a result of the overrepresentation of female teachers has been advocated as a reasonable contributor to gender variations in reading (Serafini, 2013; Smith, 2003). In essence, asking teachers to abandon "deficit thinking" about boys may be a more fruitful approach (Alloway, 2007). Yet, social and cultural constructions of gender are viable to induce literacy engagement and hence literacy achievement, as girls and boys perhaps come across contradictory expectations in their surroundings (Li, 2011). To this should be added that both constructions of literacy and pursuits eligible for reinforcing linguistic attainment are ofttimes feminized (Watson, Kehler, & Martino, 2010).

Therefore, the aim of this study is twofold; we sought to explore the relationship between (i) mnemonic recourses and (ii) demographical attributes of Greek-speaking middle school-age students (attending third, fourth, and fifth grade of primary school), and their performance in language testing. Initially, a succinct literature review is carried out and then the above affiliations are probed by apposite statistical analyses. In particular, the correlation of children's verbal STM and WM (arithmetic memory) with their achievement in reading fluency and reading comprehension, respectively, the effect of students' gender on their fluency during reading and of their school grade on their vocabulary knowledge, along with the predictive value of their age on their reading fluency, are assessed.

2. Literature Review

Several studies at international level have canvassed the connection between memory and learning, which is now taken for granted (Berninger & Richards, 2002; Dehn, 2008; Swanson, 2000). That said, close links have been descried amid mnemonic capacity and academic progress (Gathercole et al., 2006). Memory is deemed to be directly related to the development of linguistic and mathematical skills, and is held responsible for individual differences in student scholastic attainment (Gathercole et al., 2006; Passolunghi & Siegel, 2001) regardless of measurements of intelligence (Alloway & Alloway, 2010; Cain et al., 2004; Gathercole et al., 2006) and of the time needed for the completion of tasks (Seigneuric, Ehrlich, Oakhill, & Yuill, 2000; Seigneuric & Ehrlich, 2005).

Apart from reading (Smith-Spark & Fisk, 2007; Swanson & Jerman, 2007), a high correlation of memory with other language skills, such as text comprehension, has been noted (de Jong, 2006). In Greece, studies involving 9-year-old children have equated reading fluency, comprehension and range of vocabulary with metrics of WM, but not with measurements of simple verbal retention (Chrysochoou et al., 2010; Chrysochoou, Bablekou, & Tsigilis, 2011).

In effect, phonological STM, which refers to a mental workspace determined by one's ability to remember linguistic information for a brief period of time, is associated with vocabulary development and learning in general (Chrysochoou & Bablekou, 2011; Chrysochoou et al., 2013a; Karousou, 2015; Masoura, Gathercole, & Bablekou, 2004). In fact, it has been found that deficient phonological WM is also linked to learning difficulties (LDs; Alloway, 2009; de Weerdt, Desoete, & Roeyers, 2013; Kendeou, van den Broek, White, & Lynch, 2009) and neuropsychological disorders (Alloway & Gathercole, 2006).

With regard to verbal or auditory STM, language acquisition seems to pivot heavily to children's capacity to momentarily hold novel incoming acoustic information by dint of a phonological circuit (Engel de Abreu, Gathercole, & Martin, 2011). The accuracy and solidity of these transitory records conjugate them to parallel exemplifications of each word's conceptual features and constitute perpetual mapped representations in LTM (Gathercole, 2006).

In addition, characteristics like gender and the age of students in Grades 3-8 appear to alter their performance in language tests in terms of reading and understanding text passages, as well as vocabulary range and choice of opportune words (Egan & Perry, 2001; Floyd, Bergeron, & Alfonso, 2006; Martinez, Aricak, & Jewell, 2008). More specifically, it has been described that the vocabulary of boys is less rich and consists of simpler words, as opposed to that of girls –exceptionally at younger ages–, and a positive correlation of age with student reading accomplishments has been observed (Coates, 2016; Vlachos & Papadimitriou, 2015). Finally, girls seem to outperform boys in decoding and reading comprehension, to an appreciable degree (Pecjak & Peklaj, 2006).

3. Method

3.1. Research Questions

Adopting the positivist research paradigm (Robson & McCartan, 2016), a quantitative research design was actualized, that investigated the relative contributions of verbal mnemonic resources and demographical attributes of native Greek middle primary school children to their attainment in language tests. Concise approach of our research aim was endeavored through the following research questions:

1) Is there a correlation of students' verbal STM (number memory – straight digit repetition) with their performance in reading fluency?
2) Is there a correlation between students' verbal WM (number memory – inverse digit repetition) and their efficiency in text comprehension?
3) Does students' gender affect their achievement in reading fluency?
4) Does students' school grade of attendance influence their vocabulary knowledge?
5) Can students' age predict their reading fluency?

3.2. Sample and Participant Selection

The study involved 176 pupils (106 girls) from 15 state primary schools of the provincial city of Volos, Greece (enrolled in third, fourth, and fifth grade of elementary school), aged 8.50 to 12.05 (mean $[M]_{age}$ = 10.11 years, Standard Deviation [*SD*] = 8.45 months). All children were Greek native speakers. Twenty seven point three per cent (n = 48) of the sample was derived from third grade, 29.0% (n = 51) from fourth grade and 43.7% (n = 77) from fifth grade. Children attending third grade had a M_{age} of 9.14 years (range = 8.50-9.61 years, *SD* = 4.05 months), children in fourth grade had a M_{age} of 10.26 years (range = 10.14-10.37 years, *SD* = 2.83 months) and children attending fifth grade had a M_{age} of 11.19 years (range = 11.09-12.05 years, *SD* = 3.52 months).

Randomized cluster sampling was applied to a geographically representative urban area, so that the sample was compatible with the population under scrutiny (Babbie, 2017; Cohen, Manion, & Morrison, 2018). Sample size was designated with reference to the table of random sample size of Krejcie and Morgan (1970); from the total (*N*) of 6,091 students attending Grades 3-5 in all 44 state primary schools of Volos during school year 2016-2017, as reported by the most recent national school census available (GSA, 2017), our sample reached a satisfying 2.89% of the target-population.

Participants partook in the study provided that they were enrolled in the Greek school since first grade and had no history of LDs or speech problems, according to their teachers. All participating students received traditional national (curriculum-based) instruction in the conventional classrooms they attended. In Greece, there is only one national curriculum and all students are taught with the same books and methods. Absolute anonymity and confidentiality were kept and children's participation in the research was voluntary, ensuing their agreement, the informed written consent of their parents/caregivers and the total cooperation of the Principal and the personnel of their school units (Mallick, Verma, & Neasham, 2005).

3.3. Materials and Measures

3.3.1. Verbal STM and WM assessment

Verbal STM and WM skills were estimated with two tasks included in the Working Memory Test Battery for Children (WMTB-C; Pickering & Gathercole, 2001), that consisted of orally presented sequences of digits at a spoken rate of one number per second (straight and backward digit recall), to weigh up the phonological and the executive component of WM multi-component model, proportionately (Baddeley, 2007b). Evaluation span started with a block of one digit and increased to a block of nine digits (six trials per block). Participants should instantly reiterate serially each of the demonstrated trails in the correct order (direct and reverse). British assignments were translated into Greek and adapted properly for the purposes of this study.

Two scores of numeral mnemonic ability (straight and inverse recall scores) were calculated from participants' performance, equal to the sum of the lists correctly recalled until the evaluation process was terminated (after the third unsuccessful attempt at the same level of difficulty); higher score values indicated better verbal STM and WM (maximum score = 16 points for the first variable and 14 points for the second).

3.3.2. Vocabulary knowledge assessment

Vocabulary knowledge was determined by utilizing Expressive Vocabulary Subscale of the Greek version of WISC-V Cognitive Functions Psychometric Assessment Tool (Stogiannidou et al., 2017), which measures students' ability to verbally define each word they hear. Procedure was interrupted (cutoff point) posterior to the incorrect definition of four consecutive words. The number of errors was subtracted by the total amount of words delineated and performance was equal to the sum of every child's effectual efforts until the evaluation was finished, with higher score value illustrating wider vocabulary range, indexed as vocabulary knowledge (optimal score = 60 points). Internal consistency (Cronbach's *alpha*) of the subscale was .91 (Cortina, 1993).

3.3.3. Reading fluency assessment

In order to measure reading fluency, Exercise 2 of Test-A Reading Project (Padeliadu & Antoniou, 2007) was used. Participants were asked to read each of 53 words of ascending difficulty that were written on a card and their answers were recorded with a high quality tape recorder. Words had a range of one to eight syllables and students were instructed to read without time pressure and to stress the words precisely as presented. Read items were scored as 0 when the reading was inaccurate (wrong stress, missing or added letters, word replacement) and as 1 when the word was decoded phonologically correctly. The process ceased after five consecutive failed decoding attempts, when students were asked to stop reading and all following items were scored as 0. Reading fluency was defined as the quotient of the number of words children read correctly by the duration of the assessment (in seconds) until it ended, without the provision of a maximal score.

Students were assessed once during sessions and later on, on the testimony of their recorded answers, triangulating data amidst three independent examiners in pairs (Clark-Carter, 2010; see section of Procedure and Setting). Agreement across ratings was computed by dividing the total amount of agreements by the total number of agreements plus disagreements, multiplied by 100, and was 94% (range: 85%-96%). On equal footing, Cohen's *Kappa* coefficient (Cohen, 1960) was statistically significant (k = 61). Both articulation accuracy and reading velocity were taken into account, whither higher score values signified greater reading fluency. Internal consistency (Cronbach's *alpha*) of the task was .87.

3.3.4. Reading comprehension assessment

Reading comprehension was gauged by administering Story Comprehension Subtest of L-a-T-o II Psychometric Criterion of Language Proficiency (Tzouriadou, Siggollitou, Anagnostopoulou, & Vakola, 2008). Item configuration in this instrument was built on the lexical, grammatical, and syntactical familiarity per tested grade and subject matter emulated the elementary schoolbooks. Students read four narrative and three expository texts of one paragraph each (97-127 words) aloud or silently and had to immediately answer orally multiple-choice questions that were made to them (materials were also available in written form; children were allowed to go back to each passage so as to search for the right quote, when needed).

Both types of discourse had diverse structure and features, as well as different level of complexity. Narrative texts expedite reader's comprehension and are easier to understand because they have a well-regulated, goal-directed schema and contain sequences that are clearer to follow. In contrast, expository passages accommodate dense information that may be unknown to students or might entail the activation of their anterior knowledge, and they have a more abstract and logical pattern (Diakidoy, Stylianou, Karefillidou, & Papageorgiou, 2005; Sáenz & Fuchs, 2002).

Questions drew upon literal and deductive comprehension (i.e., textually explicit), together with the ability to strategically find the main idea of each text, to detect incorrect information (i.e., textually implicit) and to form an opinion or speculation by reflecting on textual data (i.e., scripturally implicit; DuBravac & Dalle, 2002). Participants were advised to read silently, to counterbalance being hampered by any speech difficulties. Correct responses were rated as 1, whereas all replies after the cutoff point were scored as 0. Administration stopped when children answered falsely five out of seven questions adverting to a text; students' performance was equal to the sum of their correct responses in each passage (maximum score = 60 points). For this measure, the *alpha* coefficient was .89.

3.4. Procedure and Setting

An intra-subject research design was employed (Mertens, 2010). Tests were administered in person and individually for each student, in a steady row, as described in the previous section of the paper, and in an average session of 57.5 minutes (range = 45-88 minutes; less time spent for higher grades) that took place in a quiet school room during regular school hours, minimizing distractions. In cases where children were unable to continue, the assessment was broken up into two sessions in the same week. Process could be halted upon participants' request at any time (although this never occurred).

The administration of the tasks was conducted by three licensed and trained/certified psychologists within two months, in the second half of the school year. Neither researchers nor examiners had any acquaintance with participants and their schools prior to the study; research assistants were introduced to students by their schoolteachers.

Children's mnemonic functions and linguistic attainment were quantified on equal intervals scales. Lastly, participants' gender (male or female) and their school grade of enrolment (third, fourth, or fifth grade) were measured on a categorical scale, whereas their age (in months) was metered on a proportional scale (Roussos & Tsaousis, 2011).

3.4.1. Test-retest reliability and procedural integrity

Toward assuring test-retest reliability for each criterion administered (see section of Materials and measures) and thus temporally triangulating research findings (Bailey, 2007), examiners assessed 39 students twice on the same tasks in a period of two weeks. These data showed that Pearson's *r* correlation coefficient ranged from .734 to .862 ($r_{test\text{-}retest} = .734$, $p < .001$; $r_{test\text{-}retest} = .795$, $p < .001$; $r_{test\text{-}retest} = .862$, $p < .001$; $r_{test\text{-}retest} = .840$, $p < .001$; and $r_{test\text{-}retest} = .801$, $p < .001$, for direct and inverse digit recall, vocabulary knowledge, reading fluency, and text comprehension, accordingly). Procedural integrity was monitored on 56 of all testing trials (32%) and was an averaging 91% (range = 84%-98%).

3.5. Data Analysis

Inferential statistics were undertaken via the Statistical Package for the Social Sciences (SPSS; Version 16.0). Namely, Pearson's *r* and Spearman's *rho* correlation coefficients, independent samples *t*-test, one-way Analysis of Variance (ANOVA) of independent samples and simple regression analysis were applied. The dependent variables that were examined were reading fluency, vocabulary knowledge, and comprehension of written text, while students' verbal STM and WM (numerical memory – straight and reverse digit repetition, severally), gender, age, and school grade constituted the independent variables of the study (Howitt & Cramer, 2017; Roussos & Tsaousis, 2011).

4. Results

4.1. Research Question 1: *Is There a Correlation of Students' Verbal STM (Number Memory – Straight Digit Repetition) With Their Performance in Reading Fluency?*

Since a dependent samples research design was launched, Pearson's *r* correlation coefficient was implemented in order to assay the presumptive existence of a linkage between verbal short-term mnemonic capacity (direct digit recall) and reading fluency ($H_1 \neq H_0$). By checking the histograms of the variables "arithmetic memory (straight digit repetition)" and "reading fluency", it was noted that the two variables approximate normal distribution to a fairly satisfactory extent (see Figures 1 and 2). Also, these variables have been measured on an equal intervals scale and having examined their scatterplot, as presented in Figure 3, it was found that their interrelation is linear.

Figure 1. Histogram of the Variable "Arithmetic Memory (Straight Digit Repetition)" (Maximum Score = 16 Points)

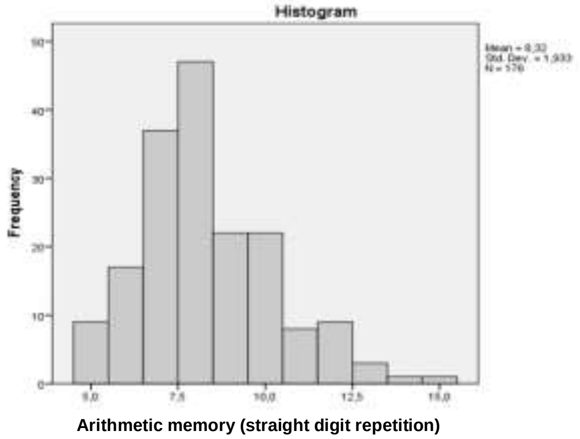


Figure 2. Histogram of the Variable "Reading Fluency" (No Maximal Score Provided)

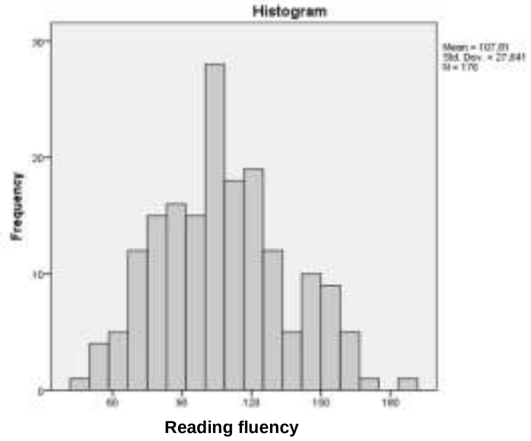
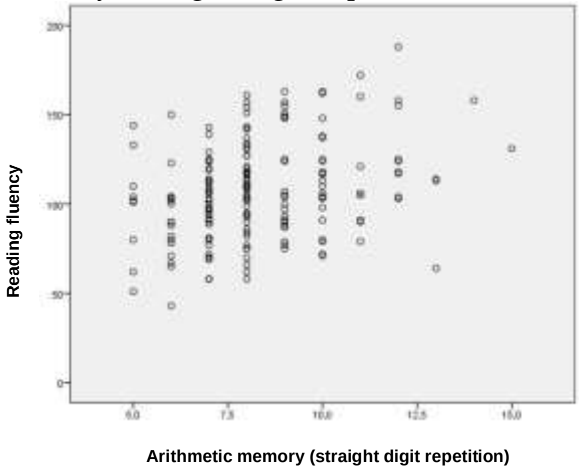


Figure 3. Scatter Graph of the Variables "Arithmetic Memory (Straight Digit Repetition)" and "Reading Fluency"



According to the results of the analysis [$r(174) = .31$, $p < .001$], in Table 1, it is observed that there is a statistically significant, low, positive linear correlation among verbal short-term mnemonic ability (direct digit repetition) and reading fluency, so null Hypothesis (H_0) is rejected and the alternative one (H_1) is accepted. Consequently, children with higher score in verbal STM skills tend to have superior reading fluency score.

Table 1: Pearson's r Correlation Coefficient Betwixt
the Variables "Arithmetic Memory (Straight Digit Repetition)" and "Reading Fluency"

		Arithmetic Memory	Reading Fluency
Arithmetic Memory	Pearson Correlation	1	.308
	Sig. (2-tailed) (*p*-value)		.000*
n		176	176
Reading Fluency	Pearson Correlation	.308	1
	Sig. (2-tailed) (*p*-value)	.000*	
n		176	176

Note: * p < .001.

4.2. Research Question 2: Is There a Correlation Between Students' Verbal WM (Number Memory – Inverse Digit Repetition) and Their Efficiency in Text Comprehension?

Given that a dependent samples research design was applied, Spearman's *rho* correlation coefficient was utilized in the interest of gaining information on a plausible connection amid verbal WM aptitude (reverse digit recall) and comprehension of written text ($H_2 \neq H_0$). After the review of their histograms, the variables "numeric memory (inverse digit repetition)" and "reading comprehension" appear to follow a slightly skewed distribution, even though they were rated on an equal intervals scale (see Figures 4 and 5); actually, the former variable is slightly oblique to the right, whilst the latter is much more oblique to the left. At the same time, the scatterplot of the aforestated variables, displayed pictorially in Figure 6, illustrated that their affinity is rectilinear.

Figure 4. Histogram of the Variable "Numeric Memory (Inverse Digit Repetition)" (Maximum Score = 14 Points)

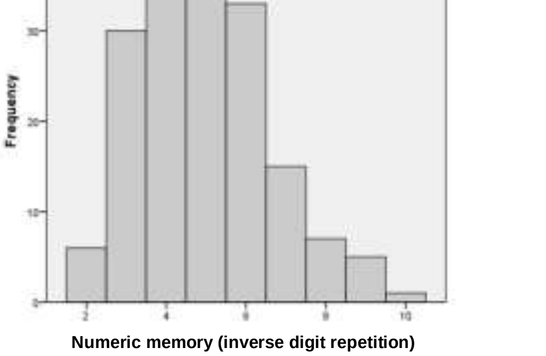


Figure 5. Histogram of the Variable "Reading Comprehension" (Optimal Score = 60 Points)

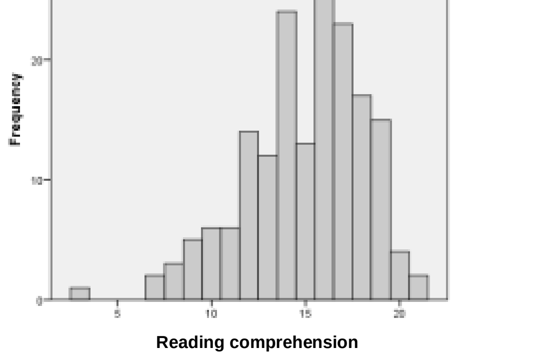
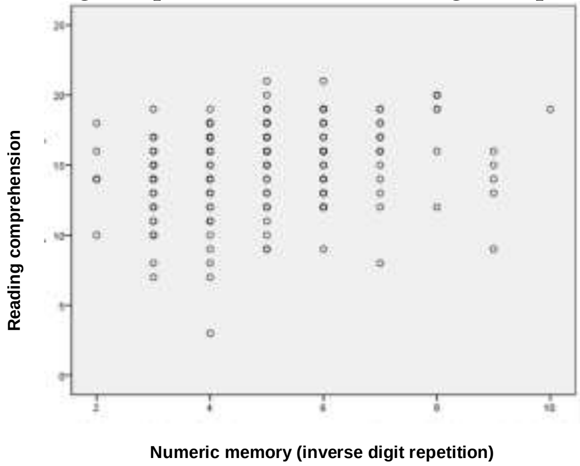


Figure 6. Scatter Chart of the Variables "Numeric Memory (Inverse Digit Repetition)" and "Reading Comprehension"



According to the results of the analysis [*rho*(174) = .27, $p < .001$], in Table 2, a statistically critical, subtle, positive linear correlation of verbal WM facility (backward digit repetition) with textual comprehension arises, thereby null Hypothesis (H_0) is renounced and the alternative one (H_2) is approved. Hence, students reaching elevated scores on verbal WM skills also demonstrate somewhat higher scores on reading comprehension.

Table 2: Spearman's rho Correlation Coefficient Amidst the Variables "Numeric Memory (Inverse Digit Repetition)" and "Reading Comprehension"

		Number Memory	Reading Comprehension
Number Memory	Correl. Coefficient	1	.271
	Sig. (2-tailed) (*p*-value)		.000*
n		176	176
Reading Comprehension	Correl. Coefficient	.271	1
	Sig. (2-tailed) (*p*-value)	.000*	
n		176	176

Note: * p < .001.

4.3. Research Question 3: Does Students' Gender Affect Their Achievement in Reading Fluency?

At first, in Table 3, the main descriptive indicators for the variable "reading fluency" are summarized by pupils' gender. Seventy boys with an average score of 107.11 points in reading fluency (*SD* = 26.10) and 106 girls with an average score of 108.27 points (*SD* = 28.72) participated in our study; the latter had marginally better attainment than the former.

Table 3: Descriptive Indicators of the Variable "Reading Fluency" by Student Gender

Gender	***n***	***M***	***SD***	**Standard Error of *M***
Male	70	107.11	26.103	3.120
Female	106	108.27	28.724	2.790

Note: Reading fluency equals the quotient of the number of words participants read correctly by the duration of the evaluation (in seconds), until procedure is recessed conforming to a specific benchmark.

Next, independent samples *t*-test was materialized, to verify the alleged deflection in mean reading fluency score among the two genders ($H_3 \neq H_0$; see Table 4). The prerequisites for this criterion are met, provided that the variable "reading fluency", as inquired for research question 1, adheres to normal distribution and has been computed on an equal intervals scale, with the subsamples being independent. In addition, the precondition of homogeneity of variances is gratified too, because the outcome of Levene's criterion is statistically insignificant (p = .221 > .05) and therefore null Hypothesis (H_0) of parity of fluctuations between the two groups cannot be dismissed.

Thus, according to the upshot of criterion t [$t(174)$ = -.27, p = .786], in Table 4, no statistically seminal difference applicable to the M_{score} on reading fluency of boys and girls is yielded, so we cannot reject null Hypothesis (H_0). Ergo, students' reading fluency does not seem to vary, predicated on their gender.

Table 4: Results of Criterion t for Independent Samples,
for the Control of Difference in Reading Fluency by Student Gender

		Levene's Test for Equality of Variances		***t*-test for Equality of Means Between the Two Genders**		
		F	**Sig. (*p*-value)**	***t***	***df***	**Sig. (2-tailed) (*p*-value)**
Reading Fluency	Equal variances assumed	1.509	.221^{ns}	-.272	174	.786^{ns}
	Equal variances not assumed			-.277	157.354	.782^{ns}

Note: *ns* = not significant (p > .05).

4.4. Research Question 4: Does Students' School Grade of Attendance Influence Their Vocabulary Knowledge?

Initially, Table 5 offers a descriptive overview of the indicators for the variable "vocabulary range" per student grade. Children have an average vocabulary score of 18.63 words (range = 2-35, *SD* = 7.92) in third grade, of 24.0 words (range = 11-36, *SD* = 6.32) in fourth grade and of 26.7 words (range = 13-42, *SD* = 6.86) in fifth grade. As expected, there was an ascending ability to achieve finer in vocabulary through the grades.

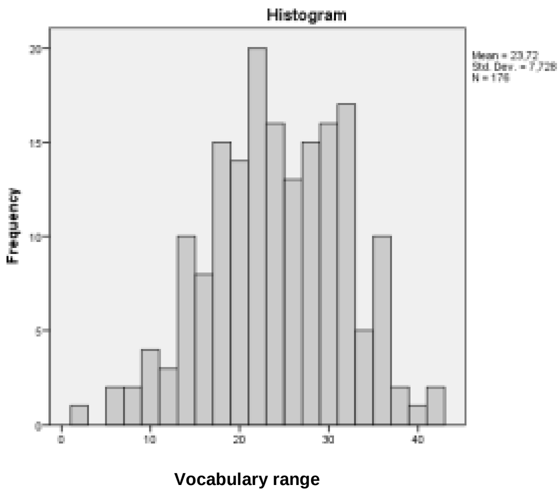
Table 5: Descriptive Indicators of the Variable "Vocabulary Range" per Student Grade

Grade	*n*	*M*	*SD*	Minimum	Maximum
3	48	18.63	7.916	2	35
4	51	24.0	6.321	11	36
5	77	26.70	6.86	13	42
Total	176	23.72	7.728	2	42

Note: In the vocabulary knowledge task, maximum score is set at 60 points or till process is ceased in compliance with a particular criterion.

Afterwards, for the purpose of ascertaining whether students' vocabulary knowledge is admittedly amended by their school grade of enrolment ($H_4 \neq H_0$), one-way ANOVA of independent samples was performed. The precondition of homogeneity of the dispersions of the three groups/grades is fulfilled, considering that the result of Levene's test is statistically non-significant ($p = .253 > .05$; see Table 6). Furthermore, the dependent variable "vocabulary range" has been gauged on an equal intervals scale and having inspected its histogram, in Figure 7, it sufficiently approximates normal distribution, whereas our three subsamples are independent.

Figure 7. Histogram of the Variable "Vocabulary Range"



On that account, according to the results of the one-way ANOVA (see Table 6), it is deducted that a statistically decisive difference in the $M_{\text{vocabulary score}}$ amidst the three grades of students occurs [$F(2, 173) = 19.645$, $p < .001$], which leads to the withdrawal of null Hypothesis (H_0) and to the acceptance of the alternative one (H_4). Thereupon, students' vocabulary knowledge varies, mediated by their grade of attendance at school.

Table 6: Output of One-way ANOVA, with "Vocabulary Range" as Dependent Variable and "Student Grade" as Independent Variable

	Sum of Squares	df	M Sum of Squares	F	Sig. (p-value)	Levene's Test Statistic (p-value)
Between groups	1934.416	2	967.208	19.645	.000*	1.387 (.253^{ns})
Within groups	8517.380	173	49.233			
Total	10451.795	175				

Note: * p < .001; ns = not significant (p > .05).

Subsequently, *post hoc* analysis was implemented, so as to test possible incongruities in individual pairs between the three grades and to find out the turning point of change for vocabulary knowledge, using Bonferroni multiple-control procedure (see Table 7). It is noticed that participants in both fourth grade ($M_{difference}$ = 5.375 words, p = .001) and fifth grade ($M_{difference}$ = 8.076 words, p < .001) obtain statistically significantly raised average vocabulary scores than participants attending third grade. The dissimilarity among fifth and fourth grade does not appear to be statistically salient ($M_{difference}$ = 2.701 words, p = .10).

Table 7: Results of Post Hoc Analysis for the Control of Differences in Vocabulary Range Between the Three Student Grades (Bonferroni Procedure)

	M Difference	Sig. (*p*-value)
Grade 4 vs. Grade 3	5.375	.001*
Grade 5 vs. Grade 3	8.076	.000*
Grade 5 vs. Grade 4	2.701	.10^{ns}

Note: * p ≤ .001; ns = not significant (p > .05).

4.5. Research Question 5: Can Students' Age Predict Their Reading Fluency?

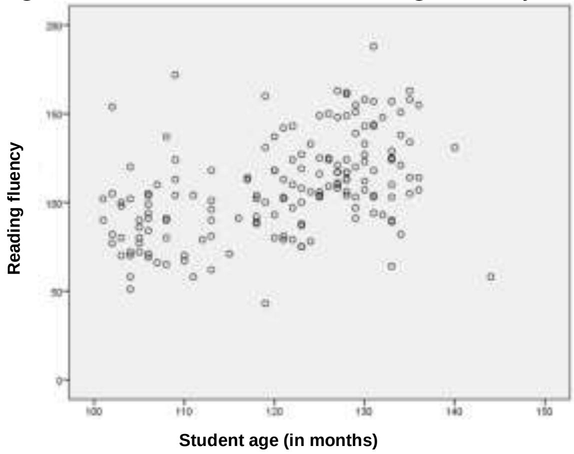
Toward prospecting if children's age is capable of predicting their reading fluency ($H_5 \neq H_0$), simple linear regression analysis was carried out. To begin with, the variables "age" and "reading fluency" have been ranked on a proportional and on an equal intervals scale, respectively, and after auditing their histograms, they adequately resemble normal distribution, while inhering in a dependent samples research design. What is more, Pearson's *r* correlation coefficient betwixt these two variables is statistically significant [$r(174) = .47$, $p < .001$], revealing a low, positive linear association of age with reading ability (see Table 8), in consonance with a linear relation of relevance amid them, as shown by their scatterplot, in Figure 8.

Table 8: Pearson's r Correlation Coefficient Among the Variables "Reading Fluency" and "Student Age"

		Reading Fluency	Student Age
Reading Fluency	Pearson Correlation	1	.466
	Sig. (2-tailed) (*p*-value)		.000*
n		176	176
Student Age	Pearson Correlation	.466	1
	Sig. (2-tailed) (*p*-value)	.000*	
n		176	176

Note: * p < .001.

Figure 8: Scattergram of the Variables "Reading Fluency" and "Student Age"



Then, it is observed that 21.7% of the total variability of reading fluency can be explained by the variability in students' age ($R^2 = .217$; see Table 9). In the meantime, according to the statistically sizeable outcome of one-way AVOVA [$F(1, 166) = 46.006$, $p < .001$], null Hypothesis (H_0) that no lineal relationship emerges between pupils' age and their reading fluency, is disavowed. In this way, our predictive model seems to be reliable. The fact that the residue of the model is homoscedastic (according to the scatter diagram of the variables) incites us to the same direction.

Table 9: Results of One-way ANOVA of Simple Regression Analysis, With "Reading Fluency" as Dependent Variable and "Student Age" as Independent Variable

	Sum of Squares	*df*	*M* Sum of Squares	*F*	Sig. (*p*-value)	R^2
Regression	27929.553	1	27929.553	46.006	.000*	.217
Residue	100775.852	166	607.083			
Total	128705.405	167				

Note: R^2 = square of correlation coefficient for our linear predictive model; * p < .001.

Beyond this, null Hypothesis (H_0) is rejected and the alternative one (H_5) is affirmed, based on the calculated statistical significance of regression coefficient *b* ($b = 1.21$, 95% Confidence Interval [*CI*] = .86-1.57, $p < .001$) coupled with standardized regression coefficient *beta* (*beta* = .47, $p < .001$), in Table 10. Therefore, we conclude that participants' age appears to be able to predict their reading fluency. In particular, the increase of their age by one month is causally connected to a boost in their reading fluency of 1.21 points.

Table 10: Estimated Coefficients of Simple Regression Analysis, With "Reading Fluency" as Dependent Variable and "Student Age" as Independent Variable

	B	**Standard Error**	***Beta***	***t***	**Sig. (*p*-value)**
Constant	-38.042	21.680		-1.755	.081[ns]
Student Age	1.212 [.86-1.57]	.179	.466	6.783	.000*

Note: B = regression coefficient b (values in brackets represent a 95% CI); Beta = standardized regression coefficient beta; * p < .001; ns = not significant (p > .05).

5. Discussion

The present paper offered insight into the contributions of verbal STM, WM and demographic features of middle school-age students whose mother tongue is Greek on their performance in language tests. The majority of the findings of this study seem to corroborate the existing literature on the relationship between children's memory skills and their linguistic proficiency (de Jong, 2006; Pecjak & Peklaj, 2006; Smith-Spark & Fisk, 2007; Swanson & Jerman, 2007). More specifically, a statistically lucid association of verbal STM and WM with reading fluency and text comprehension was accordingly distinguished, in line with research studies where measurements of the potential of WM retained their eminent involvement in English-speaking students' spelling, reading fluency and reading comprehension even up to the age of 11 (Alloway & Alloway, 2010; Cain et al., 2004; Gathercole et al., 2006).

Indeed, fluency, both as automatic single-word reading and fast efficient, smooth, and coordinated text reading (Berninger, Abbott, Vermeulen, & Fulton, 2006), has been evinced to exert crucial predictive influence on reading comprehension and on global reading achievement by evolving progressively over primary school years (de Jong & van der Leij, 2002; Fuchs et al., 2001; Hintze, Callahan, Matthews, Williams, & Tobin, 2002).

5.1. Impact of Verbal STM and WM Resources on Mature Greek Readers' Native Language Development

A noteworthy relationship among phonemic awareness and reading performance for Greek readers comes to the fore. Despite the eventual acquisition and automatization of the reading process in Greek from the first grades of elementary school owing to the orthographic translucency of Greek language (Georgiou et al., 2010; Martin et al., 2003; Seymour et al., 2003), morphological irregularities attributed to its historical nature (Goswami, 2013) might be more evident in elaborate texts read by older students, that contain several words they have not previously encountered or have only fractionally represented in terms of grammatical and semantic properties. One could assume that the escalating frequency of expository text occurrence throughout primary school age and the language tackled in these texts, which becomes more difficult, constitute factors that play a prominent role in children's comprehension, as replicated in Greek students enrolled in Grades 2-6 (Diakidoy et al., 2005).

Thus, older readers of Greek may increasingly utilize strategically a system of immediate retention and of concurrent processing of information, such as WM –not least regarding short-term phonological decoding–, rather than consolidated linguistic knowledge. Similarly, in spite of the autonomy of vocabulary development from WM already at the age of 9.5 (Chrysochoou et al., 2013a), middle school-age pupils' WM is still solicited during procedures of textual information processing at a later time (e.g., formulation of questions that require inferences to be drawn; Chrysochoou et al., 2011).

Likewise, the eventual contribution of simple (serial) mnemonic retention skills in textual comprehension could be justified by the fact that the multiple-choice questions that concretized reading comprehension in our study claimed that children merely recognized information, instead of locating and retrieving it from memory, whilst readers had the option to look up the assessment materials in order to answer, thereby facilitating the syntactic and semantic processing of passages. On the contrary, 9-year-old Greek-speaking students' attainment in replying to demanding questions of conjecture and of control of apperception from memory appears to be predicted only by their vocabulary and by their simultaneous serial storage and processing of information (Chrysochoou et al., 2011).

Arguably, it has also been documented that 9-year-old children do not face serious obstacles in answering semantically congruent literal and deductive questions (i.e., textually explicit-type questions) and in identifying semantically incongruent inconsistencies (i.e., textually implicit questions) in text if occasionally they are prompted with hints and cues like resolution or substitution and reduction, which are fundamental in textual coherence maintenance (Bowyer-Crane & Snowling, 2005). This may stem from the fact that by middle primary school students start adopting assistive strategies so as to grasp the meaning of more challenging texts (e.g., deriving and making use of text-specific knowledge) and have adequate prior knowledge, which is necessary to respond to inferential questions; on another note, this might complicate readers' efforts to assimilate the text, as they are not yet able to combine the aforementioned abilities with flexibility, rigor and automaticity (DuBravac & Dalle, 2002).

Especially Greek children in third through fifth grade exhibit weak competency in vocabulary-dependent and evaluative questions (i.e., scripturally implicit-type questions) equally met in narrative and expository discourse (Padeliadu & Antoniou, 2014). These two text genres necessitate different processing mechanisms, with the former being explanation focused and the latter being metacognitively driven (Diakidoy et al., 2005; Horiba, 2000). Presumably, by accustoming students to diverse text genres as early as elementary school and to assessment queries that oblige variant levels of inference making, experts may enhance their literal and non-literal comprehension competence (Duke, 2000).

In any case, verbal WM at an older age could be critically involved in deciphering the semantic qualities of new words. Luxemburgish 10-year-olds' native and foreign (German) vocabulary (as indexed by receptive or expressive tasks) has been found to be related to digit recall, non-word repetition and backward digit recall, but not to executive functions (dual task coordination, sustained attention, and verbal fluency; Engel de Abreu et al., 2011). In another study, measures of English vocabulary and verbal WM (complex span tasks) were associated at 10.5 years (Cain et al., 2004). Also, listening span, counting span, and receptive vocabulary of French-speaking children interacted at 8 years, howbeit not at 7 years (Seigneuric & Ehrlich, 2005), inasmuch as significant relationships between native French 10-year-olds' performance on complex span tasks (including sentences, words, digits, or numbers) and their vocabulary knowledge have been traced (Seigneuric et al., 2000). This relationship remained momentous even in early adolescence as regards English vocabulary range in 9.5-year-old Greek-speaking students (Gathercole & Masoura, 2005). Finally, both verbal WM and STM made a joint contribution to Greek 8.5-year-olds' vocabulary knowledge (Chrysochoou et al., 2013a).

This evidence not surprising, seeing that reading skills, which are intensively developed on the bounds of primary school age, share a common factor with verbal STM, WM and vocabulary knowledge over this period regardless of the type of vocabulary task (receptive or expressive; Kramer, Knee, & Delis, 2000; Walley et al., 2003). Learning to read accurately expands vocabulary knowledge, thus increasing dependence on verbal STM and WM recourses to foster new word learning. Greek children's dependency on STM and WM is also justifiable if we take into consideration that Greek students have a year less experience at elementary school, in comparison with their English peers (in the United Kingdom children enter primary school at 5, in Greece at 6), possibly resulting to the undermining of the literacy acquisition of the former (Mastropavlou, 2010; Tsimpli, 2001).

Still, learning lengthy words or the several parallel forms that words take in Greek as prerequisites for reading fluency and comprehension, might actually postulate sophisticated auditory analysis and set heavy phonological storage demands even during advanced stages of learning. It has been empirically documented in southeastern American fourth-graders that predictors pertinent to real-word decoding yield strong connections with comprehension (Jenkins, Fuchs, van Den Broek, Espin, & Deno, 2003), insofar as only word decoding and fluency are consistently correlated with all comprehension measures across all grades of elementary school (Jenkins, Fuchs, Espin, van den Broek, & Deno, 2000). In like manner, natural text reading prosody/intonation, not text reading rate, explained additional variance in reading comprehension performance, when decoding efficiency and language comprehension were controlled for in Dutch students attending Grades 4-6 (Veenendaal, Groen, & Verhoeven, 2015). Put differently, when children have to use ineffectively their cognitive means with a view to decode fluently, they do not invest in comprehension (NRP, 2000). Even in mature readers, decoding is a consequential predictor of text understanding (Catts, Hogan, & Fey, 2003; Hosp & Fuchs, 2005; Snowling, 2001).

Besides, the role of lexical representation, which is upheld by basic reading skills, ameliorates reading comprehension problems for Greek students in middle and upper elementary school grades (Protopapas et al., 2007). At that time of reader maturity, notwithstanding capitalized linguistic (phonological, grammatical, and semantic) knowledge in the first years of primary school, Greek children may not only lean on certain regularities (e.g., clear rules guiding word modifications akin to their grammatical functions) to support short-lived representations of new words (Chrysochoou et al., 2013a). Furthermore, students of advanced school grades are often unable to figure out the meaning of a word just by handling contextual clues (Sáenz & Fuchs, 2002).

Contemporaneous maintenance of the phonological form and semantic interpretation of new words may pose compelling requirements on more general WM, executive resources –rather than on specialized, phonological storage– to endorse vocabulary acquisition yet in older and linguistically experienced children (Engel de Abreu et al., 2011). Controlled processing might also promote meaning extraction of new lexical items in their wider precinct (e.g., semantic, syntactic, or pictorial), as well as grammatical processing of novel words. Such treatment accounts for a vital part of real world vocabulary growth minutely in highly inflectional and derivational languages like Greek, where words undergo disparate mutations with respect to their grammatical functions in particular frameworks (Georgiou et al., 2008; Goswami, 2013; Porpodas, 2002; Seymour et al., 2003).

Nonetheless, decrease of variegations in phonological awareness and sensitivity with age and growing linguistic experience, as observed in the relation among these measures beyond 8 years (Fuchs et al., 2001; Morra & Camba, 2009; Spear-Swerling, 2004), could construe the small magnitude of the correlations in this study. Withal, current findings are feasible to be accredited to re-integration, a cognitive mechanism assisting progressive storage and activation of exhaustive short-term linguistic knowledge in LTM (Masoura et al., 2004).

However, all explanations allude to a developmental continuity in the contributions of verbal STM and WM to native language development, because increase in age was revealed to be linked to superior reading fluency in our research. To boot, vocabulary knowledge was contingent upon students' school grade, evincing an incremental advancement, but providing initial evidence of a kind of ceiling-effect in vocabulary resources at fifth grade, which did not differ from fourth grade.

Bearing in mind the fact that reading appears to be the only key academic skill (versus writing and mathematics) that does not abide by a statistically significant relationship with the age covariate in adulthood (Kaufman, Kaufman, Liu, & Johnson, 2009), transition from fourth to fifth grade might mark the onset of Greek children's established linguistic knowledge; this finding may reflect that maturity to read is quite optimal at that grade level, coinciding with almost the end of elementary school and the entrance of students to a more textually exacting environment. In general, in a native Greek student sample, there seems to be an acute correlation between reading comprehension and vocabulary knowledge in Grades 1-6, whereas in secondary education (Grades 7-9) vocabulary knowledge turns out to be a cogent predictor of reading comprehension (Padeliadu & Antoniou, 2014).

5.2. Gender Fluctuations in Children's Reading Fluency: Possible Explanations

In contrast to preceding research (Coates, 2016; Pecjak & Peklaj, 2006; Vlachos & Papadimitriou, 2015), no statistically significant difference in reading fluency amid the two participant genders came forth in our study. There is evidence suggesting that general intelligence is highly correlated with reading achievement in 10-year-olds (Logan & Johnston, 2010), but gender discrepancies in general intelligence are negligible (Hines, 2013).

Yet, several studies have outlined varying gender differences in favor of 10-year-old girls' fluency on reading whole texts, compared to singular words (Lafontaine & Monseur, 2009; Routitsky & Turner, 2003; Schwabe, McElvany, & Trendtel, 2015), and boys tend to pay less attention while reading entire text passages more frequently than girls do (Solheim, 2011). Notably, fluency in context is typically more related to reading comprehension –and therefore fluent reading– than fluency on reading lists of words (Jenkins et al., 2003). Hence, the inclusion of phrases, sentences, or text extracts instead of single words in item arrangement of administered measures could have led to meaningful gender disparities and enhanced alternative form reliability in this study (Drost, 2011).

Markedly, it has been deduced that teachers consistently rate females higher than males in language and mathematical tests from kindergarten to high school, even when cognitive assessments imply that males have an advantage (Robinson & Lubienski, 2011). Ergo, the absence of a gender achievement gap in our study can be ascribed to examiners' expertise as certified psychologists, though highlighting the need for additional interdisciplinary researcher triangulation of present results (e.g., standardized test outcomes in contradistinction to teacher ratings or school archives of student attainment; Bailey, 2007; Clark-Carter, 2010). Examiner judgement bias shall be avoided by administering in-school, observer-based screening tools that have warranted diagnostic utilities (Politimou, Masoura, & Kiosseoglou, 2015).

6. Limitations

The sampling method of this study constitutes its greatest asset, since it ensures relatively moderate representativeness of its sample, coherent to participants' age range (8.50-12.05 years). Also, the instruments chosen for the measurement of the variables are piloted and standardized, having proven decent psychometric properties with reference to internal validity (e.g., factorial, convergent, discriminant, and concurrent validity), reliability (e.g., interrater reliability, test-retest reliability), triangulation, and internal consistency (Padeliadu & Antoniou, 2007; Pickering & Gathercole, 2001; Stogiannidou et al., 2017; Tzouriadou et al., 2008; see section of Materials). At the same time, the measures selected were aptly administered in corresponding previous studies (Boyle, 2013; Chrysochoou et al., 2013a, 2013b; Dehn, 2008; Masoura et al., 2004; Padeliadu & Antoniou, 2014).

On the other hand, caution should be taken in interpreting the results of the present study, although the sample dimensions were pretty large to likely echo population estimates impartially (i.e., validating externally the generalization of findings; Creswell & Creswell, 2018). The main constraint of this study is that not many socio-demographic characteristics of students, which may affect their performance in language tests, were reported. Other limitations are that children's pre-existing knowledge of the language topics assessed was not tested before the study and that participant subgroups were unequal in terms of size and gender distribution (i.e., overrepresentation of girls; Padeliadu & Antoniou, 2014).

Likewise, despite strict researcher fidelity to a standard protocol during data collection, dissimilarities in interactions between individual examiners and participants, along with certain intrapersonal traits of the latter (e.g., students' cognitive overload, feeling of fatigue or rush to complete tasks in time, sense of researcher intrusion into their private space) cannot be precluded, conceivably tampering with some findings. As a matter of fact, children's lack of extrinsic or intrinsic incentives might have impelled them to dispute adult authority and to doubt the overall assessment situation, its importance and its relevance (Scales, 2003; Wigfield & Guthrie, 2000).

7. Recommendations for Future Research

In future, further research could evaluate the combined effect of the aforesaid parameters on students' linguistic performance. Variables such as gender, age, mnemonic capacity (arithmetical memory), and school grade appear indeed to be linked to children's achievement in language testing. Nevertheless, this attainment does not rely solely on a single determinant, but it usually hinges on a combination of factors (Chrysochoou et al., 2013b; Melhuish et al., 2008; Pinto et al., 2016). For instance, fluency alone is not enough for the accomplishment of reading comprehension (Berninger et al., 2006); vocabulary knowledge and senior order reading skills, like the ability to make inferences from different text genres, may be essential too (Padeliadu & Antoniou, 2014).

Consequently, a study utilizing a multiple linear regression model, which allows the concerted appraisal of the influence of various agents on the dependent variables under scrutiny, is reasonable to contribute in forming a more accumulative picture of the relationship amidst cognitive factors and language attainment (Howitt & Cramer, 2017). In this backdrop, intelligence also plays an imperative role in the development of reading (Naglieri & Ronning, 2000). Beneath the scope of its strong correlation with WM (Engel de Abreu, Conway, & Gathercole, 2010), research argues that they are absolutely separated (Alloway et al., 2004; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Conway, Kane, & Engle, 2003) or that they partly overlap (Ackerman, Beier, & Boyle, 2005), or even that they compose versions of the same skill (Colom, Rebollo, Palacios, Juan-Espinosa, & Kyllonen, 2004). In fact, certain researchers assert that the connection of intelligence and WM is mainly explained by the short-term storage component (rather than the processing component; Colom, Abad, Quiroga, Shih, & Flores-Mendoza, 2008), whilst others impute this correlation to information processing (Engel de Abreu et al., 2010).

Multiple linear and hierarchical regression analyses ought to shed light into the intricate interactions of intelligence, WM, and reading skills under the rationale of a causal test-effect hypothesis (Chrysochoou et al., 2013b; Tabachnick & Fidell, 2013), providing valuable information concerning the improvement of children's achievements in language projects throughout the critical developmental period of mid-childhood (Chrysochoou et al., 2011; Yovanoff, Duesbery, Alonzo, & Tindal, 2005).

Moreover, it would be interesting to estimate the interceding impact of other demographical attributes of students, like their parents' educational background, their socio-economic status and the geographical location of their residence (Hintze et al., 2002), as well as to compare the results of this study with the ones on children with LDs (Alloway, 2009; de Weerdt et al., 2013; Kendeou et al., 2009) or with neuropsychological disorders (Alloway & Gathercole, 2006). The collation of the cognitive and linguistic profile of native Greek participants against readers speaking Greek as second/foreign language is expected to grant further inquiries a cross-linguistic and a cross-cultural perspective. Actually, it can be useful to explore whether the acquisition of an orthographically consistent native language aids the procurement of a phonologically opaque second one and vice versa (Masoura et al., 2004). Stratified sampling techniques should represent demographic allocation of participants in diverse regions of Greece (i.e., urban, semi-urban, and rural schools), whereas broad group sizes shall offer more robust statistical results (Babbie, 2017; Cohen et al., 2018).

In addition, cross-sectional studies could contrast students' mnemonic ability, reading fluency and comprehension between languages of different orthographic transparency, such as Greek and English or Greek and French (Seigneuric, & Ehrlich, 2005; Seigneuric et al., 2000). Apart from languages orthographically opaque, like English and French, the relationship amid STM and WM resources and lexical reasoning skills in languages rather equivalent to Greek as regards word length and morphological variation (e.g., Italian; Seymour et al., 2003) certainly merits further investigation; in a study with Italian-speaking 8- to 10-year-old children (Morra & Camba, 2009), a composite measure of central attentional WM capacity (tapped by counting and digit backward recall) predicted learning of short over long non-words (i.e., artificial words that do not have a real meaning) mutually with utterance speed of speech. Similarly, given the high orthographic consistency of German, the efficacy and accuracy of orthographical, phonological, and meaning lexical representations in German-speaking children attending Grades 1-4 have been discovered to anticipate interindividual fluctuations in readers' text comprehension skill (Richter, Isberner, Naumann, & Neeb, 2013).

Also, longitudinal studies (extending from participants' early years up to their adolescence) are expedient to depict how Greek readers' exact shift from WM to situated knowledge influences their reading skills. Plus, these studies might stipulate the discrete or combined predictive power of crystallized (i.e., children's ability to use their acquired knowledge) and fluid intelligence (i.e., children's capability to think inductively and deductively no matter obtained knowledge) on students' academic performance (Alloway & Alloway, 2010; Chrysochoou & Bablekou, 2011; Chrysochoou et al., 2011). Students' progression from fourth to fifth grade remains to be inspected in-depth as a focal point toward the prediction of reading comprehension by virtue of decoding and/or fluency (Padeliadu & Antoniou, 2014).

STM and WM of distant or adjacent age groups may too be illustrated via alternative tasks of WMTB-C tool (e.g., non-verbal WM tasks), executive function measures (e.g., inhibition and sustained attention), or with the assignment of linguistic activities that vary in their requisites for mere mnemonic retention and/or processing of input information. On that basis, it is crucial to evaluate participants' intelligence by administering other subscales of WISC test battery and to statistically control/exclude the practicable ramifications of their chronological age growth, their linguistic surroundings, their learning readiness and learning styles, their stress or motives, and the content of reading material which children are exposed to (Chrysochoou et al., 2013b; Wigfield & Guthrie, 2000).

For example, the processing aspect of complex listening, counting, and backward digit recall tasks is posited to be managed by a central attentional resource incorporated in WM multi-component model. Temporary maintenance is supported by the model's phonological loop, gauged with assignments of pure interim storage (involving words, digits, or non-words; Pickering & Gathercole, 2001). Within an integrative approach to WM measurement, compound and plain mnemonic tasks have accordingly been viewed as indices of WM and STM operations, demarcated in terms of demands set for concomitant processing and, thus, controlled attention (Alloway, 2007b; Cowan, 2005). Latent factor analysis (Loehlin, 2011) ought to calculate simple and convoluted memory measures as manifestations of STM and WM capacity apiece.

By the same token, some previous research has mentioned that 7- to 11-year-old boys are less prone than girls to put effort into a task that they find tedious and little dutiful, while being assessed individually or outside of their own ordinary classroom or their home (Logan & Medford, 2011; Solheim, 2011; Williams, Burden, & Lanvers, 2002). Likewise, gender differences in reading literacy favorable to girls tend to be greater for narrative/fictional texts than for informational passages (Mullis, Martin, Kennedy, & Foy, 2007) and for prose/continuous texts in contrast to document/non-continuous ones

(ELINET, 2016; Kirsch et al., 2002; OECD, 2017). Veritably, regardless of their gender, Australian English-speaking first-graders struggle to understand sentences that contain non-canonical word order (passives and object relative clauses; Boyle et al., 2013) and Greek children in all elementary school grades envisage expository texts to be more difficult to comprehend than narrative texts (Diakidoy et al., 2005; Padeliadu & Antoniou, 2014).

The dimensions of gender discrepancies in linguistic performance on the grounds of conditions during implementation of language tests or their features (e.g., activities filled out severally or in groups, within schools or in extracurricular settings, comprising assorted text genres and writing styles, in print layout or by means of computerized methods) have to be elucidated in prospective research (Solheim & Skaftun, 2009). Effect sizes (i.e., Cohen's *d*; Cohen, 1992) ought to enable thorough juxtaposition of possible sex divergences across participant cohorts. Equally, the questions that disclose the major student hindrances in reading comprehension in each school grade for miscellaneous passage types can be discerned by conducting paired samples *t*-tests (Roussos & Tsaousis, 2011).

Children's gender identity could auspiciously encompass textual comprehension in conjunction with the item format of tests and readers' instruction and academic attainment. A female advantage in apprehension has already been recorded on constructed-response items versus multiple-choice items. The former oblige the student to formulate a written, open-ended reply (rather than simply selecting an option, as in the latter), and 10-year-old boys are inclined to overlook/omit those (Schwabe et al., 2015) because their visual WM enables them to memorize more elements and process optical data faster than girls (Pittorf, Lehmann, & Huckauf, 2014). In parallel, low-achieving children perform moderately better on multiple-choice items than on constructed-response items (Routitsky & Turner, 2003; Solheim, 2011). Lastly, a study of a 10-year-old English-speaking sample (Johnston, McGeown, & Watson, 2012) surmised that girls comprehended equitably well irrespective of teaching method, but that boys did better if instructed by synthetic phonetics; withal, it was the case that boys taught by analytic phonics had poorer reading comprehension than girls, underpinned by sex differences in ratio of cerebral maturation and in brain activation when carrying out reading tasks.

Beyond that, future studies should accentuate the contribution of WM to the development of spelling in Greek, seeing that this field has not yet been utterly investigated; only a study conducted in Greece showed that pupils with LDs enrolled in Grades 1-4 that display poor achievement in dictation tasks have also a reduced ability to retain verbal information in their STM (Georgiou et al., 2010). For such inquiries, appropriate tests have already been standardized on Greek population (Sideridis, Mouzaki, Protopapas, & Simos, 2008).

8. Instructional Implications

Notably, the ideal of a "balanced view" in reading instruction (i.e., no exclusive application of either synthetic or analytic phonics) is widespread nowadays (Tønnessen & Uppstad, 2015). In Greece, instead of the traditional curricular bottom-up approach to reading (i.e., teaching first decoding, then fluency, then vocabulary, and then strategies) in the succession of primary school grades, all of the above listed must be productively consolidated into research-validated and well-designed literacy instruction with varying emphasis from Grade 1. Indicatively, reading aloud texts at any student age can unveil the shortfalls that block comprehension (Padeliadu & Antoniou, 2014).

Empirically, longitudinal data have witnessed that Greek children's shortcomings in total reading performance were prevented in the first two grades of elementary school by the interventional phonological awareness and the phonological memory training during kindergarten (Papadimitriou & Vlachos, 2014). In an Italian-speaking sample, these domain-specific markers in preschool even fortified first-graders mathematical proficiency (Pinto et al., 2016), and auditory and visual temporal order thresholds of German participants attending Grade 1 had causative repercussions on their literacy development in Grade 2 (Steinbrink, Zimmer, Lachmann, Dirichs, & Kammer, 2014).

Note

Albeit non-traditional in their orientation and being non-predictive to reading comprehension except for first-graders (Padeliadu & Antoniou, 2014), non-word repetition memory tasks distributed in prospective studies have the potential to prove quite beneficial as sensitive and accurate phonological STM measures by addressing more the quality of mnemonic traces in STM and less the existing linguistic knowledge, considering that non-words or pseudowords constitute entirely unfamiliar stimuli to students (Masoura et al., 2004).

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