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A sublexical training study for spelling in a biliterate Greek- and English- speaking child*

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Abstract

RI is an emergent trilingual boy, literate in Greek and English, with difficulties in reading and spelling in both languages. Assessment with non-literacy tests revealed a deficit in phonological ability and in visual memory for sequentially presented characters. RI took part in a training programme that targeted sublexical spelling processes. Post-intervention assessment revealed improvement in reading and spelling in Greek but not in English. Assessments of lexical and sublexical skills showed improvement in nonword spelling and nonword reading for Greek. For English, there was some indication of improvement in nonword reading at delayed post-intervention testing, but no evidence of improvement in nonword spelling. Possible reasons for the difference in outcome for the two languages are considered, including the level of transparency of written Greek and English.

Keywords: spelling intervention, bilingual child, sublexical

Introduction

Developmental dysgraphia/dyslexia is a spelling and reading disorder in children and adults. Dyslexia may occur despite adequate educational instruction and where visual and sensory-motor skills are intact (World Health Organisation, 2011). Research carried out in orthographies other than English has indicated that the incidence of dyslexia is common in these as well, although the vast majority of research has been carried out with English speaking participants. In the present paper we report a case study of a seven year old multilingual boy, RI, with atypical reading and spelling performance. The first aim was to examine for an association of RI's literacy difficulties and problems in other cognitive/language abilities, following similar research with children with reading and spelling difficulties (e.g., Brunsdon et al., 2005; Kohnen, Nickels, Brunsdon, & Coltheart, 2008; Kohnen, Nickels, Coltheart, & Brunsdon, 2008; Kohnen, Nickels, & Brunsdon, 2010; Niolaki & Masterson, 2013; Niolaki et al., 2014). RI took part in an intervention programme that targeted sublexical skills. While previous intervention case studies targeting sublexical processes have been carried out with monoliterate children, intervention case studies with multilingual children are sparse and where multilingual children were included in past studies training was carried out in only of their one languages (English) (Broom & Doctor, 1995a, 1995b; Rowse & Wilshire, 2007).

The languages in which RI was literate were Greek and English. RI's third language was Portuguese, but he was only familiar with a few spoken words in this language. Written Greek is highly transparent with almost 1:1 correspondences between graphemes and phonemes for reading (Porpodas, 1991, 1999). At the end of the first year of formal schooling children are able to read even low frequency Greek words. However, spelling is less transparent as there are different graphemes to represent the same vowel phonemes (e.g., /e/ can be written with <αι> or <ε>, /o/ can be written with <ο> and <ω>) and because stem spelling is arbitrarily related to the words' etymology (e.g., <φώκια> /focja/ (seal) the letter /ω/ omega in the stem of the word). By Grade 3 these inconsistencies do not cause many problems for Greek children (Chliounaki & Bryant, 2002, 2007) as they have acquired many of the most important morphological rules that govern the choice of word-final vowel spellings. However, difficulties with stem spellings remain as this is dependent on the words'

historic orthography. Accurate spelling for these words necessitates word-by-word learning (as in the case of irregular words in English).

English orthography, on the other hand, is highly inconsistent for both reading and spelling. As a result, a number of sources of knowledge need to be acquired by the novice speller. The UK-based independent review of literacy instruction (Rose, 2006) recommends that effective teaching involve phonics, although this should not be taught independently from semantics and other language skills. Spencer (2007) tested 207 Year 2 to 6 UK pupils on 120 frequent words. He reported that word frequency and orthographic irregularity affected the pupils' spelling performance, suggesting the parallel acquisition of whole word and decoding processes for spelling in English-speaking children.

RI's reading and spelling skills were very poor, as will be shown in the assessment sections that follow. His difficulties can be interpreted within developmental theories such as those of Share (2008) and Ehri (1998, 1999, 2000). Share (2008) suggests that since all printed words are initially unfamiliar for young children, novice reading can be thought of in terms of a continuum whereby developing phonological decoding ability is key to acquiring orthographic representations for encountered words. Thus, after a few successful decoding attempts with an unfamiliar printed word a child will be able to store an orthographic representation for future automatic word identification – the 'self-teaching' hypothesis. Share argues that inability to develop phonological decoding skill will therefore hamper reading and spelling development. Ehri's (1998, 1999, 2002) phase theory of reading development similarly proposes that following the mastery of phonic decoding skills, when printed words are encountered several times their full orthographic representations come to be stored for subsequent instant word recognition.

The dual-route (DR) theory of skilled reading and spelling processes (e.g., Barry, 1994; Coltheart, 1981) has been used extensively in single case intervention studies with children older than RI (e.g., Broom & Doctor, 1995a, 1995b; Rowse & Wilshire, 2007; Brunsdon et al., 2002; Brunsdon et al., 2005). According to the DR model, two routes or sets of processes are necessary for accurate reading and spelling. Novel and low frequency letter strings are dealt with via the sublexical route, which

consists of rules relating spelling to sound, whereas high frequency regular words and irregular words are processed by the lexical route, which consists of word-specific stores for orthographic, phonological and semantic information. As well as being used as a framework for intervention studies, DR theory has been employed in investigations of potential underlying deficits in cognitive processes associated with literacy difficulties. The research findings will be discussed next since, in the present study, we explored associated cognitive deficits that RI may have had.

Phonological processing abilities include identification and manipulation of the subcomponents of words (phonemes, syllables and rimes), and the ability to retain phonological information over a short period of time. A great deal of research carried out with English-speaking children has indicated a strong association of difficulties in phonological processing and reading and spelling difficulties (e.g., Hatcher, Hulme & Ellis, 1994; Broom & Doctor, 1995a; Brunsdon, Hannan, Nickels, & Coltheart, 2002). In addition, longitudinal studies in both opaque and transparent writing systems have demonstrated the importance of phonological ability (henceforth: PA) for later good reading and spelling performance (e.g., Caravolas et al., 2001 for English, Lervag & Hulme, 2010 for Norwegian, Nikolopoulos et al., 2006 for Greek).

Rapid automatized naming (RAN) has also been found to be impaired in children with reading and spelling difficulties (c.f. Sunseth & Bowers, 2002; Moll & Landerl, 2009). In a recent study Stainthorp, Powell and Stuart (2013) investigated the association between spelling performance and RAN in children with an average age of eight years. They found that RAN made a significant contribution to spelling performance above the association between PA and spelling. Further investigation of a group of poor spellers with a RAN deficit, who were matched in age, verbal and nonverbal ability, PA and visual acuity to a group of children with no RAN difficulty, indicated that the former group was significantly poor in spelling irregular words. This is the first paper to demonstrate an association between RAN and irregular word spelling. The researchers suggest that RAN is associated with the ability to establish good orthographic representations.

In a cross-sectional study of predictors of dyslexia with children acquiring literacy in six different orthographies Landerl et al. (2013) reported that both PA and RAN predicted dyslexia in a group of 1,114 dyslexic participants. However, the

strength of this association was modulated by orthographic transparency, with stronger associations found for opaque than transparent orthographies.

Deficits of visual memory have been associated with poor reading and spelling. Goulandris and Snowling (1991) reported JAS who exhibited a difficulty in visual memory, as well as poor irregular word spelling but preserved nonword spelling. The authors suggested the visual memory problems may have led to difficulty in acquiring whole word orthographic representations. Romani et al. (1999) found impaired visual sequential memory in a developmental surface dysgraphic adult.

Research has recently focused on other non-phonological deficits which could underlie poor reading and spelling. For example, a deficit in multi-character processing ability has been investigated with letter report tasks in English and French dyslexic children (Bosse et al., 2007; Valdois et al., 2003). Lallier et al. (2014) examined the strength of association between letter report and reading speed in two groups of dyslexic and typically developing bilingual Spanish and French speaking children. The researchers reported that letter report tasks predicted reading speed irrespective of the characteristics of the orthography and successfully discriminated typically developing from atypical readers. Niolaki and Masterson (2013) and Niolaki et al. (2014) reported Greek-speaking monolingual children with characteristics of surface dyslexia (relatively accurate nonword reading and spelling but long reading latencies) with impaired letter report but preserved PA and rapid naming ability.

In the present study RI was given assessments of the above abilities in order to examine potential reasons for his literacy difficulty. These assessed PA, rapid naming, visual memory and letter report. We also carried out detailed testing of RI's reading and spelling in order to examine potential differences in manifestation of his difficulties in Greek and English. The results of this testing were used to determine the focus of an intervention that RI took part in and that is reported in the second part of the paper.

Case study

RI was aged 7;04 when first assessed. He is an emergent trilingual in English, Greek and Portuguese. He was literate only in English and Greek. At home he spoke mainly English (and some Greek and less Portuguese) to his parents. At the age of 4 he

started the Pre-Nursery and, the following year, the Nursery class at a Greek school and he has attended the two following primary grades there. RI speaks Greek at school on a day to day basis and this is the main language of instruction. Although RI became fluent in spoken Greek at an older age than English, his level of spoken Greek and English when he was assessed for the study were both good, and this is supported by his scores in receptive vocabulary assessments (in Table 1 below). At RI's school children are taught all curriculum subjects (language, mathematics, history and science) in Greek. They also receive ten hours per week of instruction in English, which involves English literacy (oral and written communication skills). At home RI has continued to use English more than Greek in oral communication and every afternoon he has a tutor who supports him with his English homework.

At the time the assessments commenced RI was attending Grade 2. According to his Greek and English teachers he was poor at reading and spelling in both languages. Children in Grade 2 are typically able to read almost all Greek real and nonsense words, to spell to dictation high frequency words, and they are starting to realize the consistency of inflectional spelling. In English they are typically able to spell a pool of high frequency regular and irregular words and they have been taught letter sounds and letter names (Riley, 2007). During the two nursery school years Greek children develop vocabulary as well as listening and speaking skills. Reading and writing is not formally taught, however, some children enter Grade 1 being able to read a pool of high frequency words and to spell their name.

RI's parents reported that from the time that he was under two years old he suffered frequent ear infections and this had affected his hearing ability. He had grommets inserted in both ears as part of his treatment. After the operation the frequency of the ear infections was less but he still suffered in the winter time. RI had difficulty in pronouncing /l/ and when he was 5 years old he attended speech therapy for 6 months.

Background assessments

The results of background assessments conducted with RI are given in Table 1. The Matrix Analogies Test (Naglieri, 1985) was used to assess non-verbal reasoning ability and the Wechsler Intelligence Scale for Children (WISC-IV, Wechsler, 2003) was used to assess arithmetic ability and verbal working memory. The word and non-

word list recall subtasks from the Working Memory Test Battery (Pickering & Gathercole, 2001) were also administered. The above assessments were all carried out in English. Since RI had suffered intermittent hearing problems in early childhood we included assessment of current auditory discrimination abilities. For English we used the Wepman,Test (Wepman, 1972) and, for Greek, the auditory discrimination subtask from the Athena Test (Paraskevopoulos, Kalatzi-Azizi, & Giannitsas, 1999).

(Table 1 about here)

Assessment of receptive vocabulary was conducted in English and in Greek. For English, the British Picture Vocabulary Scale (Dunn et al., 1997) was used, and for Greek the Peabody Picture Vocabulary Test, adapted for Greek by Simos, Sideridis, Protopapas, and Mouzaki (2011), was administered. For the latter test normative data are not available. RI's performance was contrasted with that of an age and non-verbal ability matched comparison group (N=18, mean age=7;04, SD=0;03) for assessments where standardized norms were unavailable. The comparison group consisted of bilingual Greek- and English-speaking children attending the same school as RI. All were reported to be exhibiting average levels of literacy ability by their class teacher. In order to investigate if there were significant differences in the scores of RI and the comparison group modified t-tests (Crawford & Howell, 1998) were used. Significant differences are indicated in the tables of results by asterisks. Any differences reported are one-*tailed*. Inspection of Table 1 reveals that there was no indication of difficulty in any of the background assessments.

Literacy assessments

Table 2 gives the results of reading and spelling assessments for Greek and English. Assessment of RI's spelling in English revealed that he could spell some high frequency words (e.g., *we, is, big, look*). He could not apply phoneme-grapheme correspondences when the graphemes consisted of two letters, and especially when vowels were involved (e.g., *er, ur*). His spelling errors in the WIAT-II-T spelling subtest (Wechsler, 2006) were phonologically inappropriate on 80% of occasions (e.g., *candy*-> CADE, *right*-> RADE, *jumped*-> JPING). He also made some letter

reversals. In Greek he was able to write high frequency words (such as, από /apo/ (from), έλα /ela/ (come), και /ke/ (and), είναι /ine/ (is)), however in consonant clusters he frequently omitted letters (e.g., *στ (st),φρ (fr), χν (xn)*).

The spelling test of Mouzaki et al. (2007) was used as the standardized assessment for Greek. RI made phonologically inappropriate errors on 77% of occasions (e.g., *τραπέζι* /trapezi/ (table)-> ΤΑΠΕΖΙ /tapezi/, *χρήματα* /xrimata/ (money) -> ΧΙΜΑΤΑ /himata/). Single word reading in Greek was assessed using the words from the Mouzaki et al. test. The test was standardized (for spelling) on a sample of 580 Greek monolingual students attending Grades 2 to 5. According to the manual the reliability is α=.91. It has a discontinue criterion of six consecutive errors and maximum correct score of 60. The words in the test are from Greek primers and the authors suggest that it assesses different spelling patterns and morphosyntactic rules. Mean length of the words in the test is 7.6 (*SD*=2.9). As the Mouzaki et al. test does not include standardised norms for reading we report number of words correctly read and spelled in Table 2 (as well as RI's standard score equivalent for spelling).

We compared RI's scores in these assessments with those of the same age comparison children. RI's score was significantly lower than that of the comparison group in both spelling and reading, $t(10)=5.6$, $p<.0001$, $r=0.87$ and $t(12)=8.1$, $p<.0001$, $r=0.91$, respectively. In terms of standardized score for spelling, RI's accuracy (10 words correct) was less than the lowest score recorded for his age in the standardized scores in the manual.

(Table 2 about here)

RI was also assessed in reading and spelling in English with a list of 60 words from Masterson et al. (2008). His scores were significantly lower than those of the comparison group, $t(18)=3.4$, $p=.002$, $r=0.62$ and $t(18)=2.2$, $p=.022$, $r=0.46$, for reading and spelling respectively. For Greek reading and spelling of the same (translated) list, RI again scored significantly lower than the comparison group, $t(14)=8.1$, $p<.0001$, $r=0.91$ and $t(13)=4.1$, $p<.0001$, $r=0.75$, respectively. In spelling the list, RI made 87% phonologically inappropriate errors in English and 56% in

Greek, whereas the comparison group made 27% such errors for English and 3% for Greek. RI's high rate of phonologically inappropriate errors in Greek spelling is contrary to the finding that the rate of these is usually low in transparent orthographies (e.g., Nikolopoulos et al., 2006).

Detailed assessment

Further testing was carried out to investigate lexical and sublexical reading and spelling processes, and to assess for possible deficits of PA, visual memory, rapid naming and letter report.

Reading and spelling of irregular words and nonwords

RI was assessed in irregular word and nonword reading and spelling in English using the Diagnostic Test of Word Reading Processes (DTWRP, Forum for Research in Language and Literacy, 2012). In the DTWRP there are 30 regular words, 30 irregular words and 30 nonwords. For the purposes of the present study only irregular words and nonwords were used. The DTWRP irregular word and nonword lists do not differ in number of phonemes, letters and syllables (all Fs<1). Split half reliability for reading based on a sample of bilingual children was .82 for the irregular words and .85 for the nonwords.

In the absence of an available standardized test for Greek at the time the research was conducted the stimuli from Loizidou et al. (2009) were adopted. These consist of 20 irregular (for spelling) words and 40 nonwords. Half the items in each set are short (two to three syllables) and half are long (four to five syllables). Irregular words are those in which the vowel should be spelled with a grapheme that deviates from the predominant phoneme-grapheme correspondence. The results of the assessments are presented in Table 3.

(Table 3 about here)

The results revealed difficulty in lexical and sublexical processes in both languages. For Greek, RI scored lower than the comparison group in real word and nonword reading, $t_{Greek\ word\ reading}(14)=3.4$, $p=.001$, r=0.67 and $t_{Greek\ nonword\ reading}(14)=3.4$, $p=.002$, r=0.67, and irregular word and non-word spelling, $t_{Greek\ irregular\ spelling}(8)=2.7$, $p=.015$, r=0.69, $t_{Greek\ nonword\ spelling}(8)=10.6$, $p=.0001$, $r=0.96$. For English, RI was significantly worse than the comparison group at irregular word and

non-word reading, $t_{English\ irregular\ reading}(17)=2.5$, $p=.01$, r=0.52, $t_{English\ nonword\ reading}(17)=3.6$, $p=.001$, r=0.66, and irregular word and non-word spelling, $t_{English\ irregular\ spelling}(9)=2.9$, $p=.009$, r=0.70, $t_{English\ nonword\ spelling}(9)=2.2$, $p=.027$, r=0.59.

Phonological ability

RI's phonological skills were assessed using phoneme segmentation, deletion and transposition tasks for English from Hatcher's (1994) screening battery, plus the blending subtest from the Comprehensive Test of Phonological Processing (CTOPP, Wagner, Torgesen, & Rashotte, 1999). To assess phonological ability in Greek a blending task from the Athena Test (Paraskevopoulos, Kalatzi-Azizi, & Giannitsas, 1999) was used and phoneme segmentation, deletion and transposition test adapted from Porpodas (2002). In addition, a spoonerisms task was employed in both languages. For English, this was the full spoonerisms subtest of the Phonological Assessment Battery (Frederickson, Frith, & Reason, 1997). In this, the child is asked to exchange the first sound of two spoken words (for example, *King–John* becomes "jing-kon"). An equivalent spoonerisms test was devised in Greek (for example, γάτα:/yata/(cat)-φίλος:/filos/(friend) becomes φάτα:/fata/-*γίλος*:/yilos/). Reliability coefficients range for the English task between α=.95-.91. For the Greek task, based on a sample of bilingual Greek- and English-speaking children, the reliability coefficient was α=.94. A summary of the results from these tasks is given in Table 4.

(Table 4 about here)

RI's performance was weaker than that of the comparison group in the blending tasks, although the difference was only significant for Greek, $t(15)=2.9$, $p=.005$, $r=.60$. Assessment in phoneme segmentation and deletion tasks for English indicated that RI's performance was low average (for both tasks he obtained standardized scores of 85). In the Greek segmentation, deletion and transposition tasks he was not able to score and his performance was significantly lower than that of the comparison group, $t_{segmentation}(18)=4.1$, $p<.0001$, $r=.69$, $t_{deletion}(18)=1.6$, $p=.05$, $r=.32$ and $t_{transposition}(18)=2.02$, $p=.02$, $r=.43$. RI scored significantly lower than the comparison group in the spoonerisms tasks in both languages, $t_{English}(14)=1.8$, $p=.044$, $r=.43$ and $t_{Greek}(12)=2.9$, $p=.007$, $r=.64$.

RI was also assessed in rapid naming in both languages using the pictures and digits subtasks of the Phonological Assessment Battery (Frederickson et al., 1997).

The results are given in Table 4. RI's performance in rapid naming of digits and pictures did not indicate any deficit.

Visual memory

In order to assess visual memory four tasks were used. The memory for pictures and designs subtests from the Athena Test (Paraskevopoulos et al., 1999) were used to assess visual memory for simultaneously presented arrays. The testee is asked to reproduce either a series of abstract designs (in the case of Memory for Designs) or familiar pictures (in the case of Memory for Pictures) after a five second retention interval. The testee is provided with a set of cards (no distractors) with which to reconstruct the order of the test array on each trial. The number of items presented increases within each subtest and the total number of trials in each subtest is nine. Testing begins with three cards presented on each trial and goes up to six cards. The testee has two opportunities to provide a correct response at each array length, the first is scored with 2 points the second with 1, and after two consecutive incorrect responses at a particular array length the test is discontinued. Correct responses are considered those where the test array is reproduced in the correct order.

The third (simultaneous presentation) visual memory assessment consisted of a task adapted from the one described by Hulme (1981). The task in the present study used Arabic characters, which acted as unfamiliar symbols for RI. Arrays of 2, 3 or 4 characters were presented on the screen of a DELL Inspiron computer for 10 seconds each. A recall array was then presented after a retention interval of 1 second for the first six trials, and after 10 seconds for the following six trials. The recall array contained the test array characters in a different order and intermixed with two new characters. RI was asked to report the characters, in correct order, by pointing on the screen. There were three practice trials.

The fourth task involved sequential presentation of test array symbols and employed characters from Tamil and Devanagari. This was an adaptation of the task used by Goulandris and Snowling (1991). On each trial 2, 3 or 4 characters appeared sequentially on the computer screen for 2 seconds per character. As in the simultaneous visual memory task, a recall array was then presented following a retention interval of 1 second for the first six trials and 10 seconds for the following six trials. RI was asked to select the characters in the correct order from the recall array of characters intermixed with two distractor characters. Again, items had to be recalled in the correct order for a trial to be counted as correct. The characters for the

simultaneous and sequential memory tasks were presented in font size 80 and the tasks were designed in PowerPoint for Windows 7. RI's performance in the visual memory tasks as well as that of the comparison group is reported in Table 5.

(Table 5 about here)

The results did not indicate any difficulty in the tasks involving simultaneous presentation of stimuli, and indeed RI's performance in Memory for Designs was slightly higher than that of the comparison group. However, RI had a significantly lower score than the comparison group in the sequential visual memory task, $t(9)=4.5$, $p=.002$, $r=0.80$.

Letter report

The letter report task from Bosse et al. (2007) was employed with both English and Greek versions. At the start of each trial the screen was blank for 50 msecs then a fixation point appeared in the centre of the screen for 1000 msecs, and then the target array was presented for 200 msecs. Arrays consisted of five consonant letters, in Consolas 14 font, with .57cm spacing between letters. In the global report version of the task children were asked to report all the letters in the array on each trial. In the partial report version, children were asked to report a single letter from the array on each trial. In this version, the target letter was indicated by a cursor presented for 50 msecs, 1.1˚ below the target at the offset of the letter string. The tester noted children's responses at the time of testing and responses were also recorded for later verification.

To programme the task for presentation on the computer the DMDX software developed by Forster and Forster (2003) was used. The letters were presented in the middle of the screen of a Dell Inspiron portable lap-top with Windows 7, the video mode was 1366x768 at 60Hz. For the English version, ten uppercase letters were used (B, D, F, M, L, T, P, H, S, R) and for the Greek version, nine uppercase letters were employed (Γ, Δ, Θ, Λ, Ξ, Π, Σ, Φ, Ψ). The letter report task used only consonants, and letter combinations did not match with the skeleton of words. It was necessary to avoid letters common to the two orthographies so that the task would differ between the two languages. This resulted in the use of Greek letters with low frequency of occurrence (mean of 8,489 according to the count of Ktori et al., 2008, while the letters not included had a mean of 12,309). This could result in the Greek version of

the task being generally more difficult than the English version (and this does seem to be the case according to the results for RI and the comparison group presented below). Since Greek letter names are not frequently used and they are of two syllables and longer than English letter names, children were asked to respond with letter sounds for the Greek version of the task.

Results in the letter report tasks for RI and the comparison group are given in Table 6. RI's performance did not differ significantly from that of the comparison group for any of the letter report measures.

(Table 6 about here)

Summary of assessments

RI's ability to read and spell irregular words and nonwords was impaired in both languages. Assessment of phonological abilities indicated a deficit for both languages. For blending RI's score was lower than that of the comparison group only in Greek. This may be due to the fact that the items in the Greek blending task were more difficult (longer and with more consonant clusters). For the English task the mean number of letters was 4.2 (SD=2.6) with mainly short words of two to three phonemes, whereas for the Greek version of the task the mean number of letters was 5.3 (SD=0.9). Assessment of visual memory indicated a deficit specifically for sequentially presented characters, as in AW, the adult with developmental surface dysgraphia reported by Romani et al. (1999). RI did not exhibit a rapid naming or a letter report deficit.

Rationale for training

The results of the assessments indicated that RI had impaired single word reading and spelling in both English and Greek, and that he showed a deficit in phonological ability and visual sequential short-term memory. It was decided to provide a training that aimed at improving RI's spelling skills, since improvement in spelling as a result of training has been found to generalize to reading (e.g., Brunsdon et al., 2005; Kohnen et al., 2008a; Ouellette, 2010; Conrad, 2008). Additionally, spelling is a

harder task than reading for both Greek and English orthographies. RI was halfway through the second year of formal schooling and his ability to write was severely curtailed by poor spelling skills. At this point classmates were able to produce short passages using 'sight words' as well as using sublexical skills to spell less familiar vocabulary in both Greek and English. Thus RI's teachers and parents were concerned about his ability to cope in Grade 3.

RI's sublexical skills for reading and spelling were very weak, therefore it was decided that support for phonological skills and letter-sound awareness would be provided. Sublexical processes were chosen as the target since RI had not benefited from the phonics instruction he had received so far and it seemed important to put this skill in place before he moved on to Grade 3. Brunsdon et al. (2002) suggested that in severe cases where lexical and sublexical skills are poor it is preferable to target lexical skills. However, given that RI's language of instruction was a transparent one, and the evidence suggests more reliance on sublexical skills in the early stages for children learning such writing systems, we decided to target sublexical processes first. A description of the training is included in the next section.

Training programme

Sessions took place at RI's school over the course of nine weeks. The researcher saw RI individually for one hour per week and sessions were divided into 30 minutes devoted to training in Greek and 30 minutes in English. The order of languages was alternated each week. The procedure was the same for each session and a letter outlining what RI should do at home was given every week to his parents. Letter combinations involving vowels were taught following the order of the Jolly Phonics scheme (Lloyd, Wernham, & Jolly, 1992) for English, however for Greek letter combinations involving consonants were selected by the first author[1]. For English, we targeted vowel letter combinations, as these were problematic for RI in the baseline assessment, whereas for Greek we mainly targeted consonant clusters as RI frequently omitted the second letter in these.

Procedure

The training involved explicit teaching of phonics, following Hatcher's (1994) programme. It also involved the procedures used in Brunsdon, Hannan, Nickels and

Coltheart's (2002) intervention case study. The main difference between Brunsdon et al.'s study and the present one is that the programme of Brunsdon et al. focused on reading whereas spelling was targeted in this study. Sessions began with testing the words that had been used to illustrate the GPCs the previous week (apart from the first session). Each week two to four letter combinations were taught following the order of the Jolly Phonics scheme, for example in the first week the English graphemes <ou> and <ow> and the Greek clusters <μπρ> /br/ and <στρ> /str/ were taught. Each was related to a word that RI was asked to sound out and then write, based on the procedure of Brunsdon et al. (2002). For example, if the target was <oy>, RI was presented with the digraph written on a card and was then asked to look at a card with a word beginning/including/ending with that digraph (e.g., <boy>). RI was asked to read and repeat the word three times, following the tester. Then he was asked to copy the letters, in upper and then lower case, and then the word. If he copied without error then he was asked to write the word again after a ten second delay. This procedure was followed for each new letter combination. The training included 42 words in each language which contained the targeted graphemes.

The next part of each session included phonological activities, following Hatcher's (1994) Sound Linkage programme. The focus of the activities changed each week and covered conceptualizing words as part of sentences (week 1), syllabic awareness (week 2), phoneme blending (week 3), rhyme (week 4), phoneme discrimination and identification (week 5), phoneme segmentation (week 6), deletion of phonemes (week 7), substitution of phonemes (week 8) and transposition of phonemes (week 9).

Following the phonological activity in each session, RI was prompted to write one or more sentences (the structure of the sentence was subject-verb-object) incorporating sounds and words taught during the intervention. At this stage, following the method used in Reading Recovery intervention sessions (Clay, 1993), RI was asked to cut the sentence/s up into words, syllables and phonemes and then blend them in order to reconstruct the words and finally the sentence/s. Then he was asked to write the sentence again. Sometimes in the same session he was also asked to construct the words using plastic letters placed in word boxes (Elkonin, 1971). Phonological activities in Greek were devised equivalent to those just described.

At the end of each lesson a letter with activities was given to RI's parents and they practiced with him every day after school for twenty minutes. In this letter, RI's

parents were advised to pronounce consonants without adding a vowel (for example, "sun" should be pronounced /s/, /u/, /n/, and not "suh" "u" "nuh"). They were also asked to use letter sounds and to avoid using letter names as the training aimed to support phoneme-grapheme knowledge. Activities including the following were proposed: "Please ask … to find the new letters in magazines to cut out and stick in his notebook. Please ask … to cut out pictures with simple names that include the letter sound in different positions (beginning, middle and end). Under each picture he should try to write the name of the object in the picture. If he cannot write the word, you should help by saying it in a stretched out fashion. When …finishes the activity he should read the words he has written. In that way … will make his own sound book." Finally, directions regarding the teaching of the letters and sounds were given to RI's parents as follows:

1) Show a card with the letters on it to …..

2) For each card … should say the sound that it makes, not the name.

3) … should then say words which include the sound (at beginning, middle and end).

4) Remove the flashcard and ask … to write the letters

5) If … cannot remember how to write the letters go back to step 1.

6) When … can correctly sound out and write this letter combination you should move on to the next one.

This procedure was followed every day, and RI's parents were asked to alternate practice in Greek and English across days.

Results

At the end of the intervention RI was assessed in word and nonword reading and spelling, as well as in reading and spelling the 42 items in each language that included the trained GPCs. The assessment was carried out one month after the end of the training (Time 2), due to the fact that RI was ill and off school for four weeks immediately after training ended. There was then a delayed follow-up assessment four months later (Time 3). Seven children who had been tested before the training

were again assessed in the tasks at Time 3 (that is, at the same time as RI's delayed follow-up assessment). This was in order to see whether general maturation effects might be able to account for any changes we observed in RI's performance. The results of the assessments are given in Table 7.

(Table 7 about here)

Analysis of Greek reading and spelling results

i. Spelling and reading of words with trained GPCs

RI's post-test scores for the items with trained GPCs were compared with those of the comparison group using modified t-tests. For spelling, the results revealed that RI's score was significantly worse than that of the comparison group at Time 2 (as it had been at Time 1), $t(7)=2.3$, $p=.031$, $r=0.65$, and this was also the case at Time 3, $t(7)=2.2$, $p=.037$, $r=0.64$. For reading, which was assessed at Time 3 only, a large improvement over the pre-training score was observed; however, RI's score was still significantly different from that of the comparison group, $t(7)=2.7$, $p=.019$, $r=0.71$. McNemars tests were used to examine the significance of change in scores across timepoints. For spelling, the difference between Time 1 and Time 2 was significant, $\chi^2=5.1$ $p=.016$, r=0.41, but the difference between Time 2 and Time 3 was not. For reading, the difference between Time 1 and Time 3 was highly significant, $\chi^2=27.03$, $p<.0001$, r=0.83.

ii. Spelling and reading nonwords, spelling irregular words and reading words

There was no change in RI's spelling accuracy for irregular words across the timepoints (5% accuracy at Time 1, Time 2 and Time 3), and the score was significantly worse than that of the comparison group, $t(7)=3.4$, $p=.007$, $r=0.79$. For word reading, although RI's score improved, it was still significantly worse than the comparison group result at Time 2, $t(7)=5.5$, $p<.001$, $r=0.90$, and Time 3, $t(7)=3.5$, $p=.006$, $r=0.79$. For nonword spelling, at Time 2 RI's score was significantly worse than the comparison group, $t(7)=5.5$, $p<.001$, $r=0.90$, and this was the case at Time 3

as well, $t(7)=3.5$, $p=.006$, $r=0.79$. For nonword reading, a significant difference was observed at Time 2, $t(7)=3.3$, $p=.008$, $r=0.78$ but not at Time 3, $t(7)=1.8$, $p=.55$, $r=0.56$.

Analysis with McNemars tests revealed a significant change in RI's word reading accuracy between Time 1 and Time 2, $\chi^2=5.14$, $p=.016$, r=0.58, but not between Time 2 and Time 3. Analysis of the change in scores for nonword spelling revealed that there was a significant change from Time 1 to Time 2, $\chi^2=15.1$, $p<.0001$, r=0.65, but then from Time 2 to Time 3 there was a significant decrease in RI's score, $\chi^2=4.16$, $p=.041$ r=0.37. For nonword reading the increase in score between Time 1 and Time 2 was marginally significant, $\chi^2=3.2$, $p=.063$, r=0.34, while the increase from Time 2 to Time 3 was highly significant, $\chi_3=6.12$, $p=.008$ r=0.44.

iii. Spelling and reading the 60-word list

In the 60-word list, relative to the comparison group at Time 2 and Time 3, RI's spelling accuracy was not significantly worse; however for reading it was, at both Time 2, $t(7)=12.6$, $p<.0001$, $r=0.89$, and Time 3, $t(7)=6.6$, $p<.0001$, $r=0.94$. Analysis with McNemars tests revealed that for spelling the increase in score between Time 1 and Time 2 was significant, $\chi^2=7.1$, $p=.004$ r=0.40, but not between Time 2 and Time 3. For reading, the change was significant between Time 1 and Time 2, $\chi^2=22.04$, $p<.0001$, r=0.62, and between Time 2 and Time 3, $\chi^2=8.1$, $p=.002$, r=0.40.

Summary of change in Greek reading and spelling

For words involved in the training, there was a significant improvement in RI's spelling from pre-test to post-test, with no significant difference in scores between post-test and delayed post-test, indicating maintenance of gain. However, accuracy at both post-test assessments was still below that of the comparison children. For reading the words in the training set there was a highly significant improvement from pre-test to delayed post-test (10% correct to 79% correct), although accuracy was still significantly lower than that of the comparison children at post-test. Results revealed improvement in nonword spelling and reading following the intervention, and for nonword reading (but not spelling) RI continued to show improvement at delayed post-test, such that accuracy was no longer significantly different from that of the comparison children. Significant improvement was also found in reading and spelling

the 60-word list - RI's spelling accuracy in the list was not significantly different from comparison group performance at either of the post-test assessments. For irregular word spelling no improvement was observed.

Analysis of English reading and spelling results

i. Spelling and reading of words with trained GPCs

For spelling words with trained GPCs, RI's score was marginally worse than that of the comparison group at Time 2, $t(7)=2.2$, $p=.032$, $r=0.58$, and at Time 3 his score did not change. For reading, which was assessed at Time 3 only, the difference was again marginally significant, $t(7)1.9$, $p=.048$, $r=058$. Analysis with McNemars tests for the significance of change revealed that for spelling the increase in RI's score between Time 1 and Time 2 was significant, $\chi^2=13.1$ $p<.0001$, r=0.58, but not between Time 2 and Time 3. For reading, the increase between Time 1 and Time 3 was highly significant, $\chi^2=32.02$, $p<.0001$, r=0.89.

ii. Spelling and reading irregular words and nonwords

RI's irregular word spelling was significantly worse than comparison group performance at both Time 2, $t(7)=3.3$, $p=.011$, $r=0.75$ and Time 3, $t(7)=2.8$, $p=.015$, $r=0.72$. For reading of irregular words the difference was not significant at Time 2 or Time 3. For non-word spelling the difference between RI's score and the comparison group at Time 2, $t(7)=6.9$, $p<.001$, r=0. 93, and Time 3, $t(7)=5.5$, $p=.001$ r=0.90, remained significant. For nonword reading too, the difference was significant at Time 2 $t(7)=3.3$, $p=.008$, $r=0.77$, and Time 3 $t(7)=2.2$, $p=.034$, $r=0.63$.

Analysis with McNemars tests revealed that for irregular word and nonword spelling the difference in RI's scores across timepoints were not significant. For irregular word reading there was a significant improvement between Time 1 and Time 2, $\chi^2=8.1$, $p=.002$, r=0.57, and a marginally significant decrease in scores between Time 2 and Time 3, $\chi^2=3.2$, $p=.06$, r=0.40. For nonword reading the increase in RI's scores between Time 1 and Time 2 was not significant, but between Time 2 and Time 3 it was significant, $\chi^2=5.14$, $p=.016$, r=0.47.

iii. Spelling and reading the 60-word list

For spelling, RI's scores were significantly worse than those of the comparison group at both Time 2, $t(7)=3.4$, $p=.007$, $r=0.78$, and Time 3, $t(7)=3.05$, $p=.011$, $r=0.75$). For reading, at Time 3 the difference was not significant. McNemars tests revealed that for spelling, the difference between the timepoints was not significant; for reading the increase at both time points was significant (Time 1 vs Time 2: $\chi^2=9.09$, $p=.001$ r=0.42 and Time 2 vs Time 3: $\chi^2=15.05$, $p=.0001$, r=0.52).

Summary of change in English reading and spelling

As for the results for Greek, analysis of gains for the words containing the treated GPCs revealed a significant improvement in both reading and spelling accuracy, although performance was still significantly poorer than that of the comparison children. Gains were not observed for nonword spelling and reading at Time 2, but RI's score for nonword reading showed an increase at delayed post-test (from 7% at Time 2 to 30% at Time 3), although, again performance remained significantly worse than that of the comparison children. Irregular word reading improved, from 17% at Time 1 to 50% at Time 2, and this was not significantly different from the comparison group performance. This was followed by a decrease to 33% correct at Time 3, which was still not significantly different from comparison group performance. In the 60-word list there was a significant improvement in RI's reading accuracy from Time1 to Time 2 and then from Time 2 to Time 3, when RI's score was no longer significantly different from the comparison group's performance.

Overall, RI mainly improved in Greek in nonword reading and spelling, whereas in English he showed the most improvement for irregular word reading. For English nonword reading there was some indication of improvement at the delayed follow-up assessment.

Standardised assessments

Post-training assessment with the standardised measures was also conducted. The tests were administered one month and then four months after the end of the training (Time 2 and Time 3 respectively). The assessments that had been used prior to training for reading, spelling and phonological ability were employed. A summary of the results is given in Table 8.

(Table 8 about here)

The results indicate that RI showed improvement in the standardised spelling test for Greek. The difference between his score and that of the comparison group was no longer significant at the second post-test assessment, but at the first it was marginally significant $t(10)= 1.8$, $p=.048$, r=.49. He also showed improvement in reading for Greek, although his score was still significantly lower than that of the comparison group post-training. Improvement was observed in the PA tasks of blending, segmentation, deletion and transposition. At Time 2 and 3, RI's performance was not significantly different from that of the comparison groups.

McNemars tests were conducted to test the significance of change in scores across the timepoints. The increase between Time 1 and Time 2 was not significant for either spelling or reading accuracy, but between Time 2 and Time 3 it was significant for reading, $\chi^2=6.12$ $p=.01$, r=0.36 and it approached significance for spelling, $\chi^2=3.2$ $p=.06$ r=0.28.

For the English assessments, there was no indication of improvement in reading, spelling or in the blending subtask. However, RI's performance in phoneme deletion, segmentation and transposition showed improvement across the timepoints so that his score in these was well within the average range at Time 3.

Qualitative analyses of spelling errors

We also investigated whether there was an increase in RI's rate of phonologically appropriate spelling errors following training. We carried out a qualitative analysis of the errors in spelling the 60-word list (Masterson et al., 2008). For English 13% of errors had been phonologically appropriate before intervention, and after the intervention at both Time 2 and Time 3 the rate was 33%. For Greek, 44% of errors were phonologically appropriate before intervention, while at Time 2 the rate was 40%, and at Time 3 it was 56%. McNemars tests were used to analyse the significance of changes. Results revealed that for English between Time 1 and Time 2 there was a significant increase, $\chi^2=18.1$, $p<.0001$, r=0.57, while between Time 2 and Time 3 there was no significant change. For Greek, between Time 1 and Time 2 there

was no significant change, whereas between Time 2 and 3 the difference was significant, χ^2=14.1, p<.0001, r=0.51.

Analysis looking at specificity of training effects

Finally, in order to examine whether any effects of the training might be specific to literacy processes the arithmetic subtest from WISC-IV was re-administered after the intervention ceased. Scores showed no change: pre-training standard score = 95 and post-training standard score = 95.

Discussion

RI is an emergent trilingual boy who had severe difficulties in reading and spelling in Greek and English. Scores from tasks assessing phonological ability showed that RI's blending in Greek was impaired, though not in English, and his performance in spoonerisms was poor in both languages. Assessments in rapid naming and letter report did not reveal any difficulties. RI's poor phonological ability is consistent with the phonological deficit found in many children with literacy difficulties (Stanovich et al., 1997; Snowling, 2000). Assessment of visual memory indicated that RI may have a selective difficulty with sequentially presented stimuli, which according to Romani et al. (1999) reflects a deficit in encoding serial order. However, we only employed one measure of sequential visual memory. More extensive testing could ideally have confirmed whether this was a reliable difficulty across stimuli and across tasks.

RI was found to have poor word and nonword reading and spelling in both English and Greek, reflecting difficulties with lexical and sublexical spelling processes. Within Share's (2008) developmental framework, outlined in the Introduction, RI's deficit of phonological decoding would impede new word learning, leading to the profile observed. Qualitative analysis of spelling errors revealed that RI made many phonologically inappropriate errors in Greek (as well as English) which is not typical for children learning a transparent orthography (e.g., Nikolopoulos et al., 2003). Doctor and Klein (1992) reported a child (three years older than RI) with a phonological deficit and difficulty in spelling in Afrikaans, which is considered to be a transparent orthography. Our findings and those of Doctor and Klein run counter to the view that children acquiring literacy in transparent writing systems who have a phonological deficit will be able to compensate for this in reading and spelling as a

result of orthographic transparency, at least in the absence of intervention. RI had the same difficulties in both Greek and English and this supports the argument of Masterson et al. (1985) and Geva (2000) that a deficit in literacy development will be apparent in both languages in bilinguals.

A training programme focusing on sublexical processes was provided since RI had not benefited from the phonics instruction he had received, and it seemed important to put this skill in place before he moved on to Grade 3. RI could not spell all the letters in digraphs or clusters. A training programme that focused on spelling was developed, based on one targeting reading that had previously been found to be effective in the case of a ten-year-old child with lexical and sublexical deficits (Brunsdon et al., 2002). Following the training in the present study, significant gains were observed in both Greek and English for spelling and reading the words that had been used in the intervention that contained the trained GPCs. Post-intervention improvement was observed in nonword reading for Greek, with some indication of improvement in nonword reading in English at the delayed post-intervention assessment only. Improvement was also observed in nonword spelling for Greek, but not for English. This could be due to the fact that vowel spelling (which was mainly trained for English) is very inconsistent in English, whereas the grapheme clusters that were trained in Greek are much more consistent. However, for English, improvement in irregular word reading was observed, as well as for reading the 60-word list. In Greek a significant improvement was observed for both reading and spelling the 60-word list. Another potential reason for the relative lack of effectiveness of the sublexical intervention in improving nonword spelling and reading in English might have to do with the fact that English language instruction was for ten hours per week for RI. If there had been more opportunity to practice English literacy skills more improvement may have been observed.

The results from the standardized spelling and reading tests revealed improvement for Greek spelling and single word reading, although the post-test result for the latter was still significantly worse than scores of the comparison children. The results from the English standardised assessments did not indicate improvement in spelling and reading or in the blending task. However, RI's phoneme deletion score improved significantly. The difference between the outcome for Greek and English could be due to the difference between the two in transparency of writing system. The

high degree of consistency of Greek means that an improvement in sublexical skills is more likely to have an impact on standardised test performance than is the case for English. An alternative explanation for the difference in gain across languages could relate to the fact, as noted above, that RI received the majority of his school instruction in Greek, thereby providing more opportunity to practice literacy skills in Greek.

We observed some improvement in RI's reading in the experimental tasks, even though the intervention targeted spelling. This is in agreement with findings of Brunsdon et al. (2005) and Kohnen, Nickels, Brunsdon, and Coltheart (2008). RI's phonological skills showed significant improvement in both Greek and English, and this is likely to have been due to the inclusion of this component in the training. This corroborates findings from Brunsdon et al. (2002) who found improvement in phoneme segmentation skills.

Kohnen et al. (2008, 2010) argue that intervention success and generalization is largely dependent on the pre-training performance of the participant, including level of severity, and intervention should be tailored on the basis of this performance. This might indicate that when sublexical processes are severely compromised training with a lexical rather than a sublexical focus may be more effective (cf. Brunsdon et al., 2002). We may have observed higher levels of improvement if the daily practice had been researcher-supervised rather than led by RI's parents during the programme, as the engagement of parents in the intervention is not a variable that can be controlled. However, assessment conducted every week in order to monitor RI's learning showed week by week improvement in comparison to baseline suggesting that the practice had been consistently carried out. Another factor limiting levels of improvement could be that training was conducted in both languages in the researcher-led session each week. We counterbalanced the order of the 30-minute sessions so that RI did not start every week with the same language, but the intervention may have been more successful if it was delivered on different days for each language. A final potential variable that may have influenced the effectiveness of the intervention is its relatively short duration. Brunsdon et al.'s (2002) sublexical intervention lasted four and a half months whereas in the present study the duration was nine weeks.

A limitation of the assessments carried out in present study is that detailed testing of letter-sound knowledge was not carried out. Although we had a measure of nonword reading and spelling in both languages which indicated RI's sublexical skill in English and Greek, a thorough assessment would have allowed us to ascertain whether the targeted correspondences were those that showed improvement. In addition, we did not carry out an assessment of spoonerisms at the end of the intervention, so it was not possible to see whether improvement in this more demanding phonological ability task was achieved, as it had been for the other phonological ability tasks. We also note that a program in which vowels and consonants were targeted in both languages would have provided a better basis for comparison and for understanding the cause of specific gains at the end of the program. However, decisions concerning the focus of intervention programmes are often motivated by pragmatic reasons. Our decision to train consonants in Greek was motivated by the fact that before intervention RI made predominantly consonant reduction errors in spelling in that language. Differences between Greek and English in the characteristics of printed vocabulary in the earliest stages of literacy acquisition meant that vowel inconsistency posed the largest problem for English spelling for RI, and this was chosen as the focus of the training in English.

A further limitation on the conclusions we could draw from the study is related to the fact that we could not report standardized scores for some of the Greek assessments, making direct comparison of gains across English and Greek problematic. However, we were able to report standardized scores for Greek spelling, which was the targeted skill in the intervention. Notwithstanding the above limitations, the findings from the standardized and experimental assessments indicated that the intervention was effective in terms of bringing about improvement in spelling in RI's main language of instruction at school, and that gains were maintained over time.

Turning to the relevance of findings, we suggest that detailed specification of the deficit(s) in literacy processes is vital for effective intervention to be provided. The findings indicate that thorough assessment of a child's skills can be effective in intervention with multilingual children, although account needs to be taken of the characteristics of diverse orthographies and further research is needed to determine the optimal techniques for different writing systems.

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Note 1: The letter combinations taught in English were: ou, ow, oi, oy, ue, u_e, ew, oo, er, ur, ir, ai,ay, a_e, ea, ee, oa, o_e, ow, ie, y, igh, i_e; and in Greek they were:
μπ/b/, ντ/d/, γγ/g/, γκ/g/, τς/ts/, τζ/dz/, μπρ/br/, στρ/str/, γκρ/gr/, ντρ/dr/, φρ/fr/, χρ/xr/, χν/xn/, ευ(/ef/-/ev/), αυ(/af/-/av/), ια/ja/, σμ/zm/, σβ/sv/, σγ/sy/, ρτσ/rts/, ρμπ/rb/, γδ/yð/, θρ/thr/, νθρ/nthr/, βδ/vð/.

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Table 1: *Standardized scores in background assessments for RI and for the comparison group (scores in bold are for assessments where standardized scores were not available and represent percentage correct, standard deviations are in parentheses)*

	RI	Comparison group mean
Non-Verbal Reasoning[α]	111	111.4 (20.2)
Arithmetic[β]	95	
Working memory[c]	90	
Word list recall[d]	122	
Non-word list recall[d]	134	
Greek measures		
Receptive Vocabulary[e]	**34**	**35.2 (15.6)**
Auditory Discrimination[f]	90	
English measures		
Receptive Vocabulary[g]	114	
Auditory Discrimination[h] (max score= 40)	**32** (above average)	

Note: [α]Matrix Analogies Test, Naglieri (1985), [β] WISC-IV arithmetic subtest (Wechsler, 2003), [c]WISC IV digit span subtest (ibid.), [d] Working Memory Test Battery (Pickering and Gathercole, 2001),[e]PPVT adapted for Greek (Simos et al., 2011), [f]Auditory discrimination (Paraskevopoulos et al.,1999), [g]BPVS II (Dunn et al., 1997) using norms for EAL, [h]Auditory discrimination, (Wepman, 1972)

Table 2: *Scores in assessments of reading and spelling in Greek and English for RI and the comparison group (scores in bold are for assessments where standardized scores were not available and represent percent correct, standard deviations are in parentheses)*

	RI	Comparison group mean
Greek measures		
Reading accuracy[a]	**27******	**96 (8.2)**
Spelling[a]	**10*****	**33 (3.9)**
	SS: <71	SS: 90.2 (7.2)
Reading 60-word list[b]	**30******	**94 (7.6)**
Spelling 60-word list[b]	**15*****	**48 (7.9)**
English measures		
Reading Comprehension[c]	103	
Reading accuracy[c]	74	
Reading speed[c]	79	
Spelling[c]	82	
Reading 60-word list[d]	**17*****	**83 (18.6)**
Spelling 60-word list[d]	**8***	**63 (24.5)**

Note: , [a]single word spelling test developed by Mouzaki et al., [b]60-word list from Masterson et al. (2008) in Greek [c]WIAT-II, Teacher's edition (Wechsler, 2006), [d]60-word list from Masterson et al. (2008) in English, **p*<.05, ****p*<.001, *****p*<.0001

Table 3: *Percent correct for RI and the comparison group in spelling and reading irregular words and nonwords (standard deviations are in parentheses)*

	RI	Comparison group mean
Greek measures		
Irregular word spelling[a]	5*	54 (17)
Nonword spelling[a]	20****	90 (6.2)
Real word reading[a]	32.5***	88 (13.5)
Nonword reading[a]	25**	91 (18.5)
English measures		
Irregular word spelling[b]	0**	61 (19.6)
Nonword spelling[b]	10****	60 (21)
Irregular word reading[b]	16.6**	67 (19)
Nonword reading[b]	3.3**	75.3 (19)

Note: [a]List of irregular words and nonwords from Loizidou et al. (2009), [b]DTWRP (Forum for Research in Language and Literacy, 2012),*p<.05, ** p<.01, *** p<.001, **** p<.0001

Table 4: *Phonological ability and rapid naming scores of RI and the comparison group (scores in bold are for assessments where standardized scores were not available, standard deviations are in parentheses)*

	RI	Comparison group mean
Greek measures		
Blending[a]	79*	119 (13)
Spoonerisms[b] (max= 20)	**0****	**14 (4.6)**
Phoneme segmentation[c] (max=6)	0***	**5 (1.2)**
Phoneme deletion[c] (max=6)	0*	**4 (2.3)**
Phoneme transposition[c](max=6)	0	**5 (2.4)**
RAN pictures[d] (in secs)	**70**	**80 (21)**
RAN digits[d](in secs)	**45**	**36 (17)**
English measures		
Blending[e]	100	117 (21)
Spoonerisms[f] (max=20)	**4***	**13 (4.7)**
Phoneme segmentation[g]	<85	
Phoneme deletion[g]	<85	
Phoneme transposition[g]	<85	
RAN pictures[h] (in secs)	**60**	**58 (8.0)**
RAN digits[h] (in secs)	**33**	**30 (8.5)**

Note: [a]Athena Test; Paraskevopoulos et al. (1999), [b]Spoonerism task devised for Greek, adapted from PhAB, Frederickson et al. (1997), [c] Phoneme deletion and segmentation (Adapted from Porpodas, 2002),[d]Rapid Naming, adapted from PhAB;(ibid.), [e]CTOPP; Wagner et al. (1999), [f]English spoonerisms task, PhAB (ibid.); [g]Hatcher (1994), [h]Rapid Naming, PhAB; (ibid.) *p<.05, ** p<.01, *** p<.001

Table 5: V*isual memory task accuracy scores for RI and the comparison group (standard deviations are in parentheses)*

	RI	Comparison group mean
Visual memory for pictures[a] (max=32)	16	17 (6.0)
Visual memory for designs[a] (max=32)	20	14.2 (4.7)
Visual memory simultaneous[b] (max=12)	7	5.7 (1.7)
Visual memory sequential[c] (max=12)	3**	7.7 (1.1)

Note: [a]Athena Test; Paraskevopoulos et al. (1999), [b]adapted from Hulme (1981), [c]adapted from Goulandris and Snowling (1991), ***p*<.01

Table 6: *Letter report task accuracy scores for RI and the comparison group (standard deviations are in parentheses)*

	RI	Comparison group mean
Greek measures		
Global report arrays correct (max=20)	0	0.3 (0.67)
Global report letters correct (max=100)	55	47.2 (11.6)
Partial report (max=50)	29	32 (3.7)
English measures		
Global report arrays correct (max=20)	3	5 (5.1)
Global report letters correct (max=100)	73	69 (13)
Partial report (max=50)	42	38 (4.8)

Table 7: *Percentage correct for RI and the (untrained) comparison group in spelling and reading irregular words and nonwords (standard deviations are in parentheses)*

	Pre-training	Post-training		Comparison group	
	(Time1)	Immediate (Time 2)	Delayed (Time 3)	Time 1	Time 3
Greek measures					
Spelling words with trained GPCs[α]	0**	16.6*	19*	61.9 (18.5)	65 (16.4)
Reading words with trained GPCs[α]	9.5****	-	78.5*	95 (5.8)	96.7 (4.2)
Irregular word spelling[β]	5*	5**	5**	54 (17)	49 (12)
Nonword spelling[β]	20****	63**	48***	90 (6.2)	90 (7.1)
Real word reading[β]	32.5***	55***	60***	88 (13.5)	94 (5.3)
Nonword reading[β]	25**	38**	62	91 (18.5)	93.3 (15.6)
60-word spelling[c]	15***	28.3	30	48 (7.9)	52.3 (14.1)
60-word reading[c]	30****	70****	83.3****	94 (7.6)	98.7 (1.2)
English measures					
Spelling words with trained GPCs[d]	0**	36*	36*	69 (16)	71.4 (14.4)
Reading words with trained GPCs[d]	2.3***	-	83.3*	92.8 (4.5)	95.2 (3.6)
Irregular word spelling[e]	0**	13*	17*	61 (19.6)	63 (15.3)
Nonword spelling[e]	10****	10****	20***	60 (2.1)	63 (7.1)
Irregular word reading[e]	16.6**	50	33.3	67 (19)	-
Nonword reading[e]	3.3**	7**	30*	75.3 (19)	-
60-word spelling[f]	8*	13.3**	20*	63 (24.5)	72 (15.9)
60-word reading[f]	17***	35*	63.3	83 (18.6)	81 (15.3)

Note: [α]42 Greek words from training, [β]List of irregular words and nonwords from Loizidou et al. (2009) [c]List, in Greek, from Masterson et al. (2008), [d]42 English words from training, [e]DTWRP (Forum for Research in Language and Literacy, 2012) [f]List, in English, from Masterson et al. (2008), *p<.05, **p<.01, ***p<.001,****p<.0001

Table 8: *Pre-training and immediate and delayed post-test results for standardized tests of spelling, reading and phonological ability (scores in bold are for assessments where standardized scores were not available and represent percentage correct, standard deviations are in parentheses)*

	Pre-Intervention (Time 1)	Immediate Post-intervention (Time 2)	Delayed Post-Intervention (Time 3)	Comparison group mean (Time 1)
Greek measures				
Spelling[a]	<71***	76*	88	90 (7.2)
Reading accuracy[a]	**27*** **	**32*** **	**45*** **	**96 (8.2)**
Blending[b]	79*	95	104	119 (13)
Phoneme segmentation[c] (max correct= 6)	0***	5	6	**5 (1.2)**
Phoneme deletion[c] (max correct= 6)	**0***	**3**	**6**	**4 (2.3)**
Phoneme transposition[c]	**0***	**2**	**3**	**5 (2.4)**
English measures				
Spelling[d]	82	82	85	-
Reading accuracy[d]	74	77	74	-
Blending[e]	100	100	100	117 (21)
Phoneme segmentation[f]	<85	93	114	-
Phoneme deletion[f]	<85	85	107	-
Phoneme transposition[f]	<85	93	100	-

Note: [a]test developed by Mouzaki et al. (2007), [d]subtest from the Athena Test (Paraskevopoulos et al., 1999), [c]task adapted from that of Porpodas (2002) by the first author, [d]WIAT-II, Teacher's edition (Wechsler, 2006), [e]subtest from CTOPP (Wagner et al., 1999), [f]Hatcher (1994), *p<.05, ***p<.001