Processes Involved in Spelling in Bilingual and Monolingual English- and Greek-Speaking Children with Typical and Atypical Spelling Performance

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Abstract

Studies carried out investigated predictors of spelling and reading in monolingual and bilingual Greek and English school children attending Years 2 to 6. Studies 1, 2 and 3 investigated underlying factors in spelling of typically developing children, monolingual and bilingual. The findings of Study 1 support the notion that spelling is a multifaceted process integrating phonological, morphological, semantic and orthographic skill (Frith 1980). The aim in Study 2 was to narrow the focus on the variables found to be most strongly associated with lexical and sublexical processes for spelling and to investigate language transfer effects. Factors associated with spelling in English of bilingual children with more or less experience with Greek were examined. Children with stronger Greek literacy skill showed more influence of phonological processes than those with weak Greek literacy skills. In Study 3, three variables were investigated in relation to the single word spelling performance of a new sample of Greek and English monolingual and bilingual children. These were phonological ability (*associated with sublexical processes*), and visual memory and letter report (both associated with *lexical processes*). The findings from Studies 1, 2 and 3 indicated that, despite the difference in transparency between Greek and English, lexical processes seem to play a more important role in spelling for monolingual children than phonologically-based processes with increasing age.

In Study 4 case studies of monolingual and multilingual English- and Greek-speaking children with spelling and reading difficulty are presented. Following identification of the deficit in each case, training was conducted that targeted lexical or sublexical processes. This study aimed to further test hypotheses regarding causal relationships among cognitive processes (Nickels, Kohnen, & Biedermann, 2010). The findings support the effectiveness of theoretically based targeted training programmes for literacy difficulties (cf. Brunsdon, Coltheart, & Nickels, 2005) and the usefulness of Dual Route models of spelling for identifying the underlying deficit.

I hereby declare that, except where explicit attribution is made, the work presented in this thesis is entirely my own.

Word Count (exclusive of appendices, list of reference and bibliography): 85, 436 words

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Chapter 1

1. Introduction

The current thesis investigated a number of child- and stimulus-related variables (including phonological ability, rapid automatized naming, morphological awareness, printed word frequency and phoneme-grapheme probability) in relation to spelling performance in children. Participants were monolingual and bilingual Greek- and English-speaking children with typical and atypical spelling performance. The research employed a single word spelling task developed in English and translated in Greek (Masterson, Colombo, Spencer, Ftika, & Syntili, 2008). According to the Dual Route model of spelling (see Barry, 1993 section 2.3.1) two different procedures are involved in competent spelling. Lexical processes are the ones associated with whole word production (particularly useful when spelling irregular words, such as *island*, which do not comply with sound-spelling rules). Sublexical processes are those involving sound-spelling rules (particularly useful with nonwords, where knowledge of encoding skill is essential). The overall aim of the current thesis is to understand better the cognitive processes involved in spelling in Greek and English monolingual and bilingual children with typical and atypical spelling performance. Interest in these particular alphabetic orthographies derives from the fact that they differ in level of transparency, with English being at the deepest end of the orthographic depth continuum and Greek being at the shallowest end, at least for reading. However, this is not the case for spelling in Greek, as Greek as well is less transparent for spelling (as will be demonstrated in section 2.2). Therefore, it will be interesting to see how cognitive processes relate to spelling in two alphabetic writing systems that differ in level of transparency. Additionally, investigation of Greek and English bilinguals' spelling performance is sparse. Furthermore, investigating the bilingual population could provide further evidence of the cognitive processes associated with spelling skill as one could suggest whether the processes involved in spelling development in a first and a second language are different or the same and how processes related to spelling in two different writing systems interact. In modern societies monolinguals are tending to be the exception and bilinguals the norm. Therefore, knowledge of intra-linguistic and cross-linguistic factors that affect spelling development of bilingual pupils is of great importance.

Studies 1, 2 and 3 report investigations of the factors associated with spelling of typically developing monolingual and bilingual Greek- and English-speaking children. These factors were examined cross-sectionally and longitudinally. The Dual Route theory of reading and spelling, according to the literature review in upcoming sections, is helpful for identifying the cognitive processes involved in reading and spelling for typically developing children and so this is used as the main theoretical framework for the investigations.

Another means of progressing understanding of literacy processes has been to examine the spelling performance of children with developmental dysgraphia. The aim has been to explain the observed literacy deficit in terms of impairment in associated cognitive processes. In Study 4 single case studies are presented of monolingual and bilingual Greek- and English-speaking children with literacy difficulties. Training programmes targeting the identified deficit were conducted with each child. It has been argued that training studies can provide a strong source of evidence for the cognitive factors that underlie literacy processes (e.g., Nickels et al., 2010). In the case of intervention studies one can control for potential intervening variables. This may happen as intervention targets the observed literacy deficit and by training the cognitive process that underlie the deficit (e.g., phonological ability in the case of a sublexical deficit) it can be observed whether improvement in reading/spelling follows. If an improvement is observed, then an association between the targeted cognitive function and reading or spelling can be inferred. Bialystok (2007) claims that although considerable research has been conducted with monolingual populations with literacy difficulties, research with multilingual students, who do not have the same initial abilities in comparison with a normal population, is restricted. Consequently, the present research with multilingual students will contribute to knowledge of literacy processes in this under-researched population.

Chapter 2

2. Theories of spelling and its development in monolingual and bilingual populations

2.1. Introduction

Study 1, 2 and 3 investigated spelling processes in monolingual and bilingual children. Spelling has not been researched as extensively as reading (Treiman, 1993). For a person to be characterized as literate he/she should fulfil two prerequisites, ability to read and ability to write. The ability to write requires a range of cognitive and linguistic skills. Competent spelling entails automatic and fluent retrieval of words for transcription. Recent frameworks of writing highlight that skill in spelling facilitates compositional writing (McCutchen, 1996; Graham et al., 1997; Berninger et al., 2002).

Until the pioneering work conducted by Read (1975) with English-speaking children, spelling was considered to be a rote learning activity. However, the research of Read, Gentry, Henderson, Frith, Ehri, Treiman and others has demonstrated that spelling acquisition is not just a rote learning process. Spelling theories will be reviewed from both a monolingual and bilingual perspective in the following sections in order to elucidate the factors that affect spelling development. Although in the literature review and in the research presented the focus will be mainly on spelling, reading ability will also be addressed throughout the thesis in order to understand atypical reading and spelling performance of monolingual and multilingual children.

Several researchers have noted that despite the diversity of languages, most of the research into literacy development and difficulties is conducted with English participants (e.g., Seymour, 2005). Harris and Hatano (1999) argued that caveats should be considered before attempting to generalize findings from the English writing system to other systems. However, research on diverse writing systems (Pae, Senvcik, & Morris, 2010; Cholewa, et al., 2010; Deacon, Wade-Woolley, & Kirby, 2009) has indicated that the stumbling blocks faced by English-speaking children are similar to those encountered by children learning other languages. Research shows that the severity of the difficulties depends on the characteristics of each writing system, encapsulated in the orthographic depth hypothesis (Frost, Katz, & Bentin, 1987), to be outlined later.

Throughout the European Union approximately 10% of the school age population speak a different language at home than the majority one (Romaine, 2004). Similarly in England, despite the overall decrease in the total pupil population, the number of English Additional Language (henceforth: EAL) students has increased significantly. According to the National Association for Language Development in the Curriculum (NALDIC, 2009) statistics collated from the School Census, the number of EAL students rose by 25% between 2004 and 2008 (N=824,380). Notably, this diversity is no longer solely characteristic of urban centres but also of areas which never before had EAL pupils (CiLT, The National Centre for Languages, 2005). Consequently, knowledge of the factors that affect literacy skills in bilingual children is important for researchers and educators alike.

Knowledge of intra-linguistic and cross-linguistic factors that affect the spelling performance of monolinguals and bilinguals can help in elaborating theoretical models, and consequently, in creating improved assessment tools and curricula, and also in finding ways to support students with literacy difficulties. Up to now, little has been known about the child- and stimulus-related factors which affect the spelling development of bilingual Greek- and English-speaking children, despite an increase in research looking into bilingualism. In the present research, data were collected from monolingual students in Greece and England in order to address the question of whether bilingual students' spelling performance differs from that of monolinguals.

The two languages under consideration in the present work lie on a continuum of spelling-sound consistency, with Greek having almost 1:1 mappings from orthography to phonology but being inconsistent for spelling, and English being inconsistent for both reading and spelling. Consequently, how these diverse writing systems affect the linguistic/cognitive systems involved in spelling in the monolingual and bilingual child is of great interest, as this has not been examined before at least for the bilingual children. Moreover, in both Greek and English, spelling development seems to be a life-long experience. This may be explained by their orthographic complexity as shown in the present work. It is important to understand the factors that affect spelling, as this can inform school practices and hopefully increase the number of children who become good spellers and consequently good writers. In that way we will help every child "read like a butterfly and write like a bee" (Pullman, 2002, p.2). In the following section the characteristics of the Greek and English writing systems will be considered, as these characteristics form the basis for understanding the factors that affect spelling acquisition.

2.2. The writing systems of English and Greek

Linguistic Variability in Writing Systems

Writing systems, or the graphic systems that represent languages, are mainly phonological or visual-orthographic. Caravolas (2005) classified writing systems into three major categories based on the discrepancy of graphemic units carrying meaning or sound:

- **Logographic:** each character transfers meaning (at the word or morphemic level). Chinese and Japanese Kanji belong to this class of writing system.
- **Syllabic:** each symbol corresponds to a syllable (sound based). Japanese Kana and Hindi belong to this class of writing system.
- **Alphabetic:** graphemes correspond to phonemes (sound based). English, Dutch, Greek, German and others belong to this category.

In the present thesis the focus will be on alphabetic writing systems, although cross-linguistic and intra-linguistic studies of logographic and syllabic writing systems will also be discussed, due to Greek and English being alphabetic. Alphabetic writing systems differ in level of orthographic depth and syllabic complexity. As noted earlier, Greek is considered to be quite transparent for reading but deeper for spelling. English is opaque for both reading and spelling, although, in English too, phoneme-grapheme correspondences are more equivocal than grapheme-phoneme correspondences (Perry et al., 2002). The inconsistency of English spelling makes it challenging even for highly literate adults. This derives from the fact that spelling is sometimes divergent from the word's pronunciation. For both Greek and English, the orthography has remained the same despite changes in pronunciation over time. This makes spelling in both languages less predictable than reading. Spelling inconsistency has been shown in analyses of English and Greek. Spencer, Loizidou, and Masterson (2010) and Spencer (2010) reported that for both languages spelling inconsistency is greater than the reading inconsistency. Similarly, with Spencer et al. (2010), Protopapas and Vlachou (2009) calculated for Greek that spelling consistency is approximately 80%, whilst in the reading direction it is 95%. In the following sections, characteristics of the two orthographies will be discussed.

The English writing system

According to Vousden (2008) 39% of graphemes, 16% of onsets, and 18% of rime mappings in English are inconsistent in terms of phonology to orthography correspondence. In this study the aim was to investigate whether the distribution of the words' frequency (derived from the CELEX database) could be a possible good fit according to the Zipf's law. Zipf's law (Zipf, 1935) predicts that the most frequent words will have a frequency of occurrence two times more frequent than the next item and then three time more frequent than the third item and so on. The importance of this awareness has useful educational implications on the type of words that should be introduced to novice readers. In Vousden's study consistency was measured on the level of whole words (frequency of occurrence- with high frequency words read faster), on the level of onset and rimes (consistency of the vowel due to the surrounding context) and on the level of grapheme-phoneme correspondences (henceforth: GPCs) (words with low probability of GPCs are read slower than with high, e.g. *pint* and *hint*). The researcher also found that knowledge of the hundrend most frequent words constitutes 56.7 per cent of the text readable and that from the 312 GPCs recorded (total number of monosyllables derived from CELEX database: 7, 195) 72 (23%) have unpredictable GPCs. Vousden concluded that sight vocabulary and GPCs should be both acquired by children in order to learn irregular words with unpredictable grapheme-phoneme probabilities and in order to learn regular words with predictable grapheme-phoneme correspondences, and that onset-rimes frequently occurring should complement those two. She also concluded that as vocabulary increases GPCs are more important than whole word reading or onset-rime mappings. This is due to the fact that GPCs will help the child read the novel word. This is also predicted by the Dual-Route model (see section 2.3.1. of the current thesis).

Other researchers have examined children's texts to calculate the level of inconsistency. For example, Stuart, Dixon, Masterson, and Gray (2003) analysed children's early reading vocabulary and found that 50% of the most frequent words are irregularly spelled (with not predictable phoneme-grapheme correspondences e.g., *have* frequency per million 3, 746). This high level of inconsistency might be expected to discourage use of phonological (or *sublexical*) strategies and encourage more reliance on whole-word, visually based (or *lexical*) strategies for reading and spelling. The researchers also developed a children's database of vocabulary appearing in books of Key Stage 1. Ziegler et al. (1997) using the Kučera and Francis (1967) linguistic corpus reported that 72% of English monosyllabic words are inconsistent in spelling. Furthermore, Kreiner (1992) reported that 60% of English words are irregular and this can lead to misspellings. The major difficulty in English derives from the fact that one sound can have many different correspondences, and these can consist of different graphemes (e.g., the sound /i:/ can be written as <ee>, <i>, <ie>, <ea>, etc). This high level of inconsistency might be expected to discourage use of phonological (or *sublexical*) strategies and encourage more reliance on whole-word, visually based (or *lexical*) strategies for reading and spelling. Wijk (1966) conducted an analysis of English and found that it has approximately 45 phonemes and over 100 written graphemes. Treiman et al. (1995) calculated that only 51% of the written vowels are consistent, while initial and final graphemes are much more consistent (96% and 91%, accordingly), as are rime units (77%). For example, <a> is inconsistent when represented in the words *mat, mall, male, mare,* but as part of the rime unit <at> it is highly consistent (*mat*, *rat*, *hat etc.)*.

Research has demonstrated the difficulties posed by the English spelling system. For example, Perry et al. (2002) conducted a spelling to dictation study with 21 students. The authors found that sounds with many correspondences were harder to spell than those with few. Other characteristics such as position of the grapheme and relation between the preceding and following consonant played a significant role in spelling. For example, Treiman, Kessler, and Bick (2002), in four experiments conducted with adult participants, found that spellers are sensitive to the context in which a vowel occurs when spelling vowels in nonwords and real words. For example, <*ea*> is frequently met in the middle position (e.g., <*steam*>); however, when followed by <*d*> or <*p*> it is spelled by <*ee*>, as in the word <*steep*> or <*steed*>. The significance of the context, position and stress of a grapheme was also found in three experiments which Treiman, Berch, and Weatherston (1993) conducted with kindergarteners and First Graders.

According to Sterling (1992) English written language is not only phonological it is also lexical and morphemic. It is lexical as words with identical pronunciation (homophones) can have different meanings and only from their written form can the reader differentiate them, for example <bean> and <been>. It is morphemic, as words which share the same root morpheme show morphemic constancy even if they are pronounced differently, for example <health> and <heal>.

Additional complexity derives from spelling of Greek and Latin origin words. For example the phoneme /f/ may be written as <f> or <ph> when it stems from Greek, (e.g. <dolphin> <δελφίνι> (delfini)). Words of Latin origin, as they adjusted into English pronunciation, became inconsistent: for example <impede> <impediment> (Treiman & Kessler, 2005). Moreover, dialects and local accents have had an influence on pronunciation. Treiman et al. (1997) examined the occurrence of /r/ before a vowel in the spellings of British, a non-rhotic and American-English, a rhotic dialect. They found that American children more often incorporated <r> in their spellings while English pupils showed the opposite pattern. Additionally, the rime in “kissed” and “list” may sound the same but is spelled differently because “kissed” is the past test of a regular verb and “list” is a single morpheme word (Chliounaki & Bryant, 2002).

English spelling irregularity also derives from the fact that it has a complex Germanic syllabic structure and incorporates a considerable number of consonant clusters. This syllabic difficulty faced by English students was shown by Duncan et al. (2006). Researchers conducted a cross-linguistic study with English- and French-speaking children (age range 4;11-to-6;08) investigating children’s segmentation skills. French-speaking children performed the tasks more effectively than English-speaking children. Researchers attributed the result to characteristics of French orthography, with 80% of French syllables being open, compared to 42% in English. According to Treiman (1993) phonemic parsing difficulties may cause spelling errors.

Another difficulty deriving from the English writing system is the presence of silent letters (for example, <lamb>, where the <b> is not pronounced). Also the merging of phonemes as in the case of the pre-consonantal nasals (for example, /mp/, /nk/, /nd/, Treiman & Kessler, 2005). As a result, English spelling is considered to be opaque and a number of sources of knowledge need to be acquired by the novice speller. Spencer (2007) tested 207 Year 2 to 6 UK pupils on the 120 most frequent words from a count of words in children’s books, the Children’s Printed Word Database (Masterson, Stuart, Dixon, & Lovejoy, 2003). He reported that orthographic irregularity affected the pupils’ spelling performance - sounds with many correspondences were harder to spell than those with few. Other characteristics, such as printed word frequency, were also associated with the children’s spelling accuracy.

However, Kessler (2009) argues that although English spelling seems to be highly arbitrary, there are rules that help disambiguate inconsistencies. For example, children rely on knowledge deriving from the preceding and following vowel or consonant in order to spell the letter in between. Similarly, adults rely on morphological knowledge or look at the rest of the word in order to spell the initial grapheme.

The Greek writing system

Although, as noted earlier, Greek is transparent for reading, with almost one-to-one grapheme-phoneme correspondences, the situation for spelling is rather different. Irregularities are primarily due to the fact that although pronunciation has changed from antiquity, spelling has remained the same. Thus, as Harris and Giannouli (1999) note, Greek spelling is based on the etymology of the words rather than their current pronunciation. There are many written words containing different graphemes representing the phonemes /o/, /i/ and /e/, since certain phonemic distinctions (e.g., between vowels represented by <η, ι, υ, οι, ει, υι> and those represented by <ο, ω>) are no longer present in the language. For example:

- The vowel phoneme /e/ can be represented by <ε> and <αι>.
- The vowel phoneme /o/ can be represented by <ο> and <ω>.
- The vowel phoneme /i/ can be represented by <ι, η, υ, οι, ει, υι>.
- The vowel phoneme /u/ is always represented by <ου> a double grapheme.
- The consonant phoneme /s/ can be represented by <σ, ς, σσ>.
- The consonant phoneme /g/ can be presented by <γκ, γγ>.
- The consonant phoneme /zm/,/zv/,/zy/ is represented by <σμ/sm/, σβ/sv/, σγ/sy/>, respectively.
- The vowel grapheme <υ> depending on the context can be silent for example <Εύβοια> /evia/ (name of a city), or it can be pronounced as /f/ or /v/.
- Double consonants make a single sound <ά**λλ**α> (a**l**a: others).
- The grapheme <π> only in the word <Πέμπτη> /pemty/ (Thursday) is voiceless.

Greek has many multisyllabic words which can have many different representations of /o/, /i/ or /e/, for example <αποτύπωμα> /apotipoma/ (footprint) or <ιδιοφυΐα> /iðiofiia/ (genius). Protopapas and Vlachou (2009) calculated that the phoneme-grapheme ratio in Greek is 1.33, lower than the ratio for English which is estimated to be 1.7 (Caravolas, 2004). Nunes, Aidinis and Bryant (2006b) point out, though, that inconsistency in Greek lies in the context of a system that is otherwise highly consistent, unlike the situation for English. In addition, the alternative spellings for the vowels are governed by morpho-syntactic rules (such as the first person of verbs ending with the vowel grapheme <–ω> /o/, while nouns end with <–o> /o/). Children are taught these rules in the early years of formal schooling, and most children master correct spelling by Grade 3. However, things are not clear-cut when one considers the stem of the word, as stem spellings are not dictated by phonology or morphology only; orthographic knowledge is also essential, for example <φως> /fos/ (light) and <είναι> /ine/ (is).

According to Nikolopoulos, Goulandris, and Snowling (2003, 2006) spelling difficulties for Greek children also stem from Greek being a highly inflected language. Consequently, an emergent literate has to learn many grammatical and syntactic rules. Giannouli and Harris (1997) carried out a longitudinal study where they assessed spelling in nursery, then in Grade 1, Grade 2 and Grade 3. They concluded from their results that Greek children need at least three years of formal schooling in order to master the basic morpho-syntactic rules. Similarly, Aidinis (1998) investigated 51 Year 2 children, 7 years old (mean age 7;01 range 6;07-7;06). He reported that reading of the vowel digraph of the ending of words soon approached ceiling, while spelling performance of the same digraph ending was only 25% accurate. Aidinis concludes that the latter reflects the inconsistency of Greek spelling in contrast to reading.

Porpodas (1999) conducted a study with first graders with typical and atypical reading and spelling performance. He assessed children's letter knowledge, non-word and word reading and spelling. He concluded that reading and spelling follow different developmental trajectories with spelling lagging well behind reading. This concurs with the work of Nikolopoulos et al. (2003). The researchers assessed Greek dyslexic pupils (aged 7- and 9-years-old) and found that they could read 90% of words and, 86% and 90% of non-words correctly at age 7 and 9 respectively. Their spelling errors were mainly phonologically appropriate. Non-phonologically appropriate errors were restricted to low frequency, multisyllabic words with difficult consonant combinations (such as, <εγκάθειρκτος> /egaθirktos/ (imprisoned)). Nikolopoulos et al. calculated that approximately 70% of the dyslexic children choose the wrong grapheme (between alternatives) ending up with orthographically inaccurate spellings that are phonetically correct. This is different from what is typically reported for English-speaking dyslexics' spelling errors. For example, Bruck and Treiman (1990) reported many non-phonologically appropriate errors, such as <BEEVER> for <believe>. Orthography clearly has an effect on children's spellings.

Similarly, Protopapas et al. (2013) in a cross-sectional study investigating classification of errors made by typical and atypical spellers with 542 typical spellers and 44 children diagnosed with dyslexia from Grades 3, 4 and 7 found that a preponderance of the errors made by both types of children were phonologically appropriate. Both groups made a large number of errors with inflexional and derivational morphemes and root stems, however in Grade 7 the latter type of error was significantly reduced.

Interim Summary

Both English and Greek violate the one-to-one principle for spelling since there are multiple correspondences between phonemes and graphemes (Cook, 2004; Spencer, Loizidou-Ieridou, & Masterson, 2010). In addition, Greek and English possess a large number of vowel graphemes corresponding to the same vowel phoneme, which makes vowel spelling challenging. English also violates the linearity principle as a child needs also to attend the ending of the word in order to spell a word correctly (for example, in the case of the split-digraph rule) (Cook, 2004). In the following sections theories of spelling and reading are presented.

2.3. Theories of printed word recognition

Luria (1970, pp 323-324) described writing as a process which involves four different steps: “The flow of speech is broken into individual sounds. The phonemic significance of these sounds is identified and the phonemes represented by letters. Finally, the individual letters are integrated to produce the written word”. Luria’s “phonic mediation theory” has been rendered untenable as cognitive neuropsychologists found evidence of spelling without phonological mediation in cases of phonological dysgraphia (e.g., Shallice, 1981). Cognitive psychologists proposed different models based on empirical evidence, acquired disorders, from computational modelling and from neuroimaging studies (e.g. Coltheart, 2006; Seidenberg & McClelland, 1992; Ans, Carbonnel, & Valdois, 1998).

2.3.1. Dual route models

According to dual route models (DR) (e.g. Ellis & Young, 1988; Barry, 1994) two routes are responsible for spelling; the *lexical* or *addressed* route is responsible for the retrieval of familiar and irregular words (*Lex* in Figure 1). This consists of a store (or lexicon) of auditory word recognition units, a word meaning store and a store of whole-word representations for written output (the orthographic output lexicon). During spelling-to-dictation, in the case of familiar words, the presented word activates the phonological representation of the word (at auditory word recognition), this is turn activates the word’s meaning (semantics) and the word’s spelling in the orthographic output lexicon. Alternatively, the *nonlexical* or *assembled* route is responsible for the encoding of unfamiliar items and non-words. This route entails parsing of the spoken input into its constituents (phonemes, syllables or other units), mapping the phonological units onto graphemic units and finally assembling the units for output. This route will succeed with regular and pronounceable pseudowords but it will fail with irregular words leading to phonologically plausible misspellings (e.g., *light* -> LITE). Output from either the lexical or sublexical route is held in the graphemic buffer (which is a short-term memory store) until a written response or oral response is provided. Figure 1 is a reproduction of a schematic of the two procedures from Barry (1994).

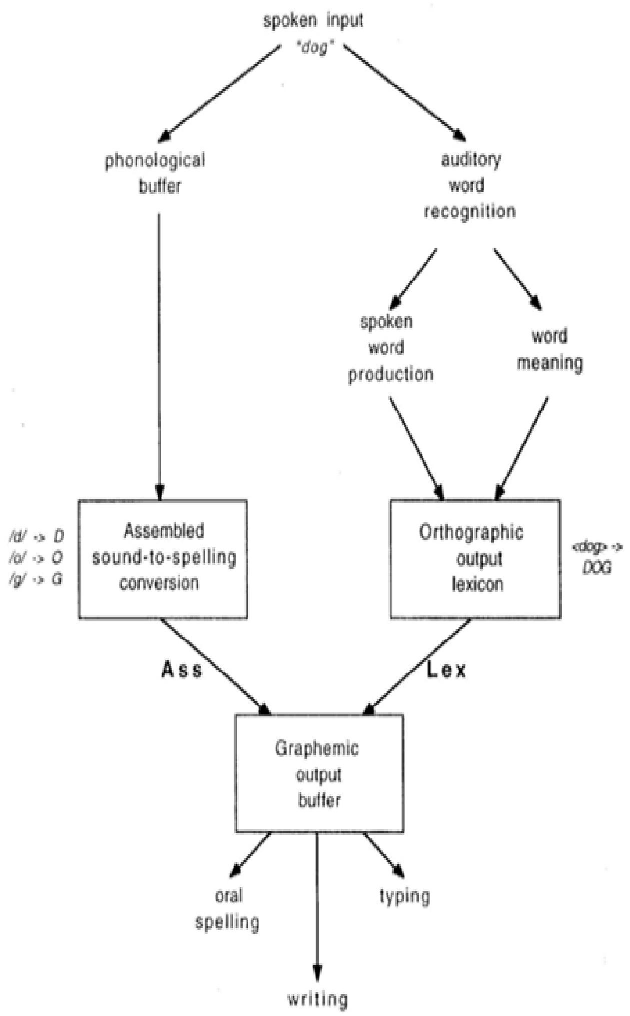


Figure 1: *The Dual Route model for spelling (from Barry, 1994, pp.32)*

Evidence for the existence of two different routes for spelling derives from people with acquired dysgraphia following brain injury. According to Ellis and Young (1988), pure cases of acquired surface dysgraphia (inability to produce once-familiar spellings for irregular words, such as *gauge, yacht,* e.g. Newcombe and Marshall, 1973; Holmes, 1973) and of acquired phonological dysgraphia (inability to use the assembled route to spell novel words, such as *dant, welp,* e.g. Shallice, 1981), provide support for the DR model.

Behrmann (1987) reported the case of CCM a 53-year-old educated woman, who was not able to provide correct spellings for irregular words. The majority of her misspellings were phonologically plausible renderings of the dictated items (e.g. *league*

-> LEEG). Her ability to accurately spell homophones was also significantly impaired. The DR model was used for identifying the malfunctioning component and to tailor an appropriate intervention programme. Similarly to CCM, Newcombe and Marshall (1985) reported the case of M.S., an acquired dysgraphic who spelled words using phoneme-grapheme correspondences (for example, *whom* -> HUM).

In contrast to the above two cases, Shallice (1981) reported PR, a phonological dysgraphic, who was tested in tasks tapping reading, spelling and comprehension after he suffered from a left hemisphere stroke. His spelling errors were mainly real word substitutions, (e.g., *custom* -> CUSTARD). PR's spelling of real words was not significantly impaired but he had a marked inability to spell nonwords (he was able to spell only two out of ten four letter items, and he was unable to spell any of the six-letter non-words). PR claimed that he used his real word knowledge in order to spell a non-word, for example he spelled SYM by analogy to *symbol.*

The cases of selective impairment, of the lexical-semantic processing or the sublexical phoneme-grapheme conversion route, provided evidence for separation of the two spelling procedures as proposed in the DR model. Evidence deriving from acquired disorders has provided a deeper understanding of the processes of spelling production and is consistent with DR models of spelling and reading. In the next section an examination of the evidence from developmental disorders of spelling and reading will be presented.

2.3.2. Developmental dyslexia/dysgraphia and models of spelling

Researchers have also reported cases of children with developmental surface, phonological and mixed dyslexia/dysgraphia. Case studies of developmental surface and phonological dyslexia/dysgraphia will be covered next.

2.3.2.1. *Case studies and group studies of participants with developmental literacy disorders*

Sublexical deficits

Cases of individuals unable to read or spell nonwords (developmental phonological dyslexics/dysgraphics) are the most frequent in the developmental research on literacy disorders (e.g., Hulme & Snowling, 1992; Snowling & Hulme, 1989; Campbell & Butterworth, 1985). These individuals are usually reported to have a general phonological impairment. Masterson, Hazan, and Wijayatilake (1995) reported two case studies of adult developmental phonological dysgraphics. Both made a large number of non-phonologically plausible errors (e.g., *athletic*-> ATHETIC) and their spelling of non-words was impaired while their reading and spelling performance with real words was unimpaired (based on standardized assessments). Both participants exhibited a marked impairment in phonological working memory and phonemic discrimination as assessed by acoustic-phonetic tests. Similarly, Snowling (2000) reported a dyslexic boy, JM, with high IQ. When JM was 8 years old, he had a single word reading age equivalent of 7;05 and a spelling age equivalent of 6;05. For reading he seemed to possess a small sight vocabulary and the majority of his reading errors were visual (e.g., *thirsty* -> TWENTY). JM's spelling errors were mainly phonologically inappropriate and this did not change during an age span from 8 to 12 years (see Table 1). His auditory discrimination was significantly impaired (e.g., he had difficulty discriminating between the words *pin-bin*). Although his phonological ability (henceforth: PA) in tasks involving syllables appeared intact, his performance in phonological tasks involving phonemes was impaired. At age 12 JM was able to read non-words at the level of a 7-year-old child.

Table 1: *Examples of JM's spelling errors at ages 8, 10 and 12 years (Snowling, 2000, pp. 7)*

Item	Age 8	Age 10	Age 12
Umbrella	Unenprl	Unbrl	Unberller
Understand	Unenstand	Undrestant	Unstand

A further case study of developmental phonological dyslexia was reported by Broom and Doctor (1995a). SP was an 11-year-old boy whose nonword reading was significantly impaired (8/32) compared to the performance of a comparison group, but his irregular word reading was intact (21/32).

Apart from single case studies there have been several group studies demonstrating phonological processing difficulties in developmental reading and spelling problems (Bradley & Bryant, 1983; Manis, Custodio, & Szezzulski, 1993; Vellutino et al., 1996). For example, Manis et al. (1993) in a longitudinal study with twenty-one dyslexic children (age 9- to 15-years-old) reported that phonological processing explained more variance in dyslexic children's reading skill and after two years children's performance in phonemic analysis did not show any improvement. Similarly, Vellutino et al. (1996) conducted a longitudinal intervention study with 1,407 children (51% boys and 49% girls). From the initial sample they included in the study 118 poor readers. They assessed the children using a large variety of language-based assessments, memory, cognitive and world knowledge measures. They also screened children's attention, organizational processes and reading and mathematical skills. On the basis of children's poor performance on phonological awareness and letter-sound mapping tasks the researchers reported that phonological processing was the core deficit for poor reading.

Lexical deficits

A number of single case studies and group studies have indicated that although developmental dyslexia/dysgraphia is conceptualized mainly as a phonological disorder, this may not be the core deficit for some children with literacy difficulties. Studies of children and adults with intact phonological skills and impaired irregular word spelling and reading have been presented (for example, Brunsdon et al., 2005; Castles & Coltheart, 1996; Goulandris & Snowling, 1991; Dubois et al., 2007; Valdois et al., 2003; Valdois et al., 2011; Hanley & Gard, 1995). Brunsdon et al. (2005) reported a 12-year-old boy, M.C., who exhibited developmental surface dysgraphia. His non-word spelling was accurate, (he spelled 27 out of 30 non-words correctly). The same was observed for his regular word spelling (20 out of 30); however his irregular spelling was impaired (12 out of 30 correct). Additionally, M.C's. performance in phonological processing tasks approached ceiling but his performance in lexical decision tasks was impaired (his results were comparable with those of younger control children). Brunsdon et al. suggested that M.C. had surface dysgraphia and that his poor performance in irregular word spelling and lexical decision was a result of impairment in lexical processes. Another single case was carried out by Castles and Coltheart (1996). They reported MI, a developmental surface dyslexic, with impaired irregular word reading. His difficulty could not be attributed to poor phonological processing ability or poor visual memory, and his spelling errors appeared to resemble application of phoneme-grapheme correspondences (See Table 2). The researchers argued that the deficit could be explained by a DR model, which differentiates between lexical and non-lexical processes. A single-route model would fail to account for such a pattern.

Hanley and Gard (1995) also reported two distinct cases of developmental surface and phonological dyslexia. The two undergraduate students were closely matched in overall reading and spelling ability, and in memory span and vocabulary. The student who had the characteristics of surface dyslexia was good at reading and spelling nonwords, had unimpaired phonological ability, had better performance in reading regular than irregular words and made mainly phonologically appropriate errors in spelling and reading. The student with the characteristics of phonological dyslexia had poor nonword spelling and reading, had poor phonological ability and he produced a few phonologically plausible errors in spelling.

Table 2: *Examples of MI's errors (Castles & Coltheart, 1996, pp.49)*

Regular	Response	Irregular	Response
Weasel	Weasl	Island	Iland
Middle	Midil	Colonel	Cornel

Interim summary

To summarize, research with developmental dyslexics and dysgraphics indicated that a single route model is not able to account for the variety of developmental disorders described in the literature. The research generally provides support for the DR model, indicating that lexical and sublexical processes are separable (see also Castles and Coltheart, 1993).

2.3.2.2. *Interrelation between the two routes*

Rapp, Epstein and Tainturier (2002) argue that the lexical and sublexical routes are not totally dissociated during normal spelling production. Evidence which favours the interaction of the two routes stems from lexical priming effects which have shown that sound to spelling mappings are influenced by the lexical route. Campbell (1983; 1985) and Barry and Seymour (1988) found that nonword spelling could be affected by a prime presented prior to the non-word. If the prime was *boys* then the non-word /vɔiz/ would be spelt as VOYS and if the prime was *noise* the non-word would be spelled as VOISE. Campbell (1983) found that approximately 71% of nonwords were written with the same vowel grapheme that the prime word had. Additionally, she reported that the effect was not significant for an acquired surface dyslexic/dysgraphic participant and she attributed it to reduced access to the orthographic lexicon.

Additional evidence for interaction of spelling processes was provided by Miceli and Capasso (2006) in a review of neuropsychological investigations of brain damaged patients. They report Hillis and Caramazza's (1991) case study, JJ. JJ had a semantic impairment but not a sublexical difficulty. JJ made 22 out of 22 phonologically plausible spelling errors for dictated words for which he did not have semantic knowledge. According to Miceli and Capasso, if the lexical and sublexical route were completely dissociated, JJ should have provided semantically related responses for words with partial semantic representation (e.g., LION instead of *tiger*). However, JJ gave mainly phonologically plausible spellings (*tiger* -> TYGUR), which indicated that during spelling production the two routes are not totally independent.

In close association Tainturier et al. (2013) investigated the impact of lexical neighbours on pseudoword spelling in a group of 71 French speaking adults. The researchers concluded that the participant more frequently spelt the item even with a low probability PGC when the item included the lexical neighbour rather than when the item did not have any neighbours. This influence was even stronger when the pseudoword had close neighbours of high frequency. Findings indicate that lexical and sublexical processes are not completely disassociated during spelling procedure and as the researchers claim that pseudowords trigger the neighbours spellings via the phonological lexicon.

2.3.2.3. *DR model of reading and spelling: Same or different?*

Barry (1994) asserts that we should not view DR theories of reading and spelling as totally dissociated. He justifies his claim by arguing that spelling ability in children generally follows reading, as soon as the latter is securely learned, and by asserting that a substantial amount of research has looked into reading establishing in this way a theoretical framework which can also be a safe reference for spelling production. The association of reading and spelling skill is also reported by Rapp and Lipka (2011) who conducted a functional magnetic resonance imaging study (fMRI). The researchers found that reading and spelling share brain regions, providing further evidence that they share cognitive processes, finding corroborates Barry's argument. Folk and Rapp (2011) came to the same conclusion based on research conducted using a nonword priming spelling task. However, Ellis (1981a & b) and Bishop (1985) argue that spelling cannot just be seen as the reverse procedure to reading. They base their claim on Bryant and Bradley's (1980, 1983) observation of the dissociation between reading and spelling. Specifically, Bryant and Bradley found that children between six and seven years old were able to spell using the nonlexical route and read relying on the lexical route. Similarly Frith (1980) reported adolescents who were average readers but poor spellers. Waters, Bruck, and Seidenberg (1985) reported that Grade 3 good readers but poor spellers used spelling-sound correspondences for both reading and spelling. This was in contrast to Frith's (1980) claim that good readers-poor spellers read "by eye" and spell "by ear". However, it is difficult to draw firm conclusions as participants in the two studies differed significantly in age.

In 2007 Bates et al. in a large scale study conducted in Australia with 1,382 monozygotic and dizygotic twins, used a common architecture to model reading and spelling. The researchers based on the research evidence claim that both reading and spelling share the same genetic bases. A single route model could not show a good fit to the data (log-likelihood, χ^2 (1) =43.3, p<.0001), while the joint reading and spelling DR model did (log-likelihood, χ^2(13) =1.65, p<.64). In the same way Rapscak et al. (2007) tested, using a simple regression analysis, the predicted validity of the dual-route equation of irregular and regular word spelling performance in 33 adults with acquired dyslexia and dysgraphia. They found a good explanation of 92.1% and 88.8% of variance respectively. Findings indicate that the DR model can successfully accommodate both reading and spelling. However, one should be aware that they are not the same procedures, as accurate reading does not require awareness of all the constituent graphemes of a target word, while spelling does (Frith, 1980; Holmes & Babauta, 2005).

This is also obvious as one cannot succeed in spelling only by practice in reading. Bosman and Van Orden (1997) demonstrated that spelling is enhanced only by teaching conventional spellings. In studies where they compared teaching of spelling with reading of words, they found that spelling instruction is superior to just practice in reading (Bosman & van Hell, 1999). In the latter study they compared the performance of seven-year-old typically developing (TD) spellers in five different groups: (a) visual dictation (the child looks at the word, the item is removed and the child writes it and checks it; in case of an error the child repeats the same procedure), (b) reading, (c) copying, (d) grapheme selection (the child looks at the word, the word is removed from sight, two graphemes are presented and the child has to circle the one that appeared in the word) and (e) oral spelling. Visual-dictation was found to be the most beneficial method for the children participating in the study. The researchers attributed this to the integration of three different strategies in the visual dictation technique: writing from memory, including kinesthetics, practicing whole word spelling and providing immediate feedback.

As shown above, the DR model has been successfully used in explaining deficits in spelling and, as we will see later in Chapter 7 it is also useful in designing appropriate interventions. There is also some evidence suggesting that some components are common to both reading and spelling. For example, Holmes and Babauta (2005) provided evidence that the same orthographic representations are used for both reading and spelling. Fifty-two university students participated in spelling tasks. Words (48 difficult to spell and 24 easy to spell) were presented in four visibility conditions (one, two, three or four end letters provided and preceding letters substituted by asterisks). In cases where students were not confident about their spelling attempt then the word they typed reappeared and they were allowed to read the misspelt attempt. Researchers found that reading of the misspelt item on most occasions helped the students improve the spelling and provide a correct response.

Research findings in favour of a single lexicon for reading and spelling were also obtained by Angelelli, Marinelli, and Zoccolotti (2011). The researchers tested Italian children with surface dyslexia/dysgraphia and younger controls. Italian is a more consistent orthography than English. The tasks used were a spelling task, administered twice in order to establish words consistently correctly or erroneously spelt and an orthographic judgment task generated according to each child's spelling performance. In the latter task participants had to decide among 160 items presented on a computer which items were correctly spelt or misspelt (half were correct and half were wrong). The researchers concluded that both typical and atypical participants found it easier to judge accurately a continually correctly spelt item than a continually misspelt item. The latter finding indicates that a single mechanism for reading and spelling also exists for these children (however, the number of participants was quite small).

In the next section the focus will be on developmental theories of spelling production in order to understand better spelling processes of monolingual and bilingual children. The theories will be approached mainly from a monolingual perspective as bilingual developmental theories of spelling production have not been reported.

2.4. Stage theories of spelling development

Models of normal skilled spelling and acquired dysgraphia have been challenged (Ellis, 1985; Frith, 1985; Seymour, 1987). The main points of critique focused on the ability of the models to adequately explain the developmental arrest exhibited by poor spellers. The gap was filled by developmental stage theories (e.g. Frith, 1985; Seymour, 1987). The pioneering naturalistic research with precocious spellers conducted by Read (1975, 1986) provided evidence that spelling is not just the result of rote learning; knowledge of phonological properties was also significant for spelling production. Read's sample was 32 children aged two to four years. Treiman (1993) mentions two limitations; the fact that the sample came only from educated families and that only misspellings were examined. However, Read was the first to claim that children's spelling mistakes inform educators about strategies and about children's metalinguistic awareness.

Following similar naturalistic studies, researchers suggested that spelling develops in distinct stages. Henderson and Beers (1980) assessed children's misspellings through a creative writing task and, by conducting qualitative analysis they matched errors to a particular stage. Stage theory was also proposed by Bissex (1980) and Gentry (1981, 1982, 2000). Bissex (1980) conducted a case study of her son's spelling development from 4 years old to 10 years old. The study provided further evidence that spelling is not just rote recitation. Researchers' observation could be summarized in the following five-stage developmental theory (Bissex, 1980; Henderson and Beers, 1980; Frith, 1980; Ehri, 1999; Gentry, 2000):

Pre-communicative stage: the speller, despite knowing a few letter-names, cannot map letters onto sounds.

Semi-phonetic stage: a few letters are used to spell and letter names are used, for example <car> could be spelled as <CR>.

Phonetic stage: misspellings are basically phonetic, so a plethora of regularization errors occur, such as <ILAVYOO> for <I LOVE YOU> (misspelling made by a four and a half-year-old girl NF observed by the author, 2010). Children at this stage have developed decoding skills which help them spell and read novel words.

Transitional stage: children follow the main conventions of English spelling and realize that more than one grapheme can often be used to represent a single phoneme.

Correct stage: children know when a word is misspelt and at this stage both lexical and sublexical processes are functioning well.

Ehri (1999) also proposed different phases of spelling development. However, she avoided the term stages. Independent, non-overlapping stages, where the first is the pacemaker for the second, do not represent Ehri's phases. In addition, she merged the two stages "Semi-phonetic" and "Phonetic" into one, the "partial alphabetic". The other phases she proposed are the same as described above.

Frith (1980) proposed three stages: the logographic, the alphabetic whose pacemaker is spelling, and the orthographic whose pacemaker is reading. Frith's developmental theory is outlined in Figure 2.

Step	*Reading*	*Writing*
1a	*logographic*$_1$	(symbolic)
1b	logographic$_2$	→ logographic$_2$
2a	logographic$_3$	*alphabetic*$_1$
2b	alphabetic$_2$ ←	alphabetic$_2$
3a	*orthographic*$_1$	alphabetic$_3$
3b	orthographic$_2$	→ orthographic$_2$

Figure 2**:** *Frith's developmental stage* theory *(Frith 1985, pp.311)*

According to Frith (1980; 1985) developmental arrest at stage 3a results in surface dysgraphia, while developmental arrest at stage 2a will result in phonological dysgraphia. Frith (1980) reported studies of children with good reading but poor spelling performance. She postulated that poor spellers-good readers rely on partial cues for reading which allow them to read words successfully, but the incomplete orthographic representations result in poor spelling performance.

Castles and Coltheart (1996) also stated that support for Frith's stage theory also comes from an in-depth case study of a 10-year-old boy who had surface dyslexia. His phonological abilities were intact but irregular word reading was significantly impaired. According to Castles and Coltheart the findings can be explained by the DR model and Frith's stage model. In terms of the latter, the child reached the alphabetic stage but after that, arrest occurred.

2.4.1. Critique of developmental stage theories

Longitudinal studies

Although Frith's (1980) developmental stage theory provides a framework to explain spelling and reading difficulties as arrest at different stages, not all researchers support all the aspects of this theory. Stuart and Coltheart (1988), in their longitudinal study of 36 four- to eight-year-old children, found that not all children follow the same developmental pathway when learning to read and spell. They reported that children who have good PA skills may skip the logographic stage. Stuart and Masterson (1992), in a longitudinal study of 20 four- to ten-year-olds found that children with good phonological processing skills at the outset of the study were later better at reading and spelling regular and irregular words than students whose phonological processing skills were poorly developed at the outset. They concluded that students with well developed pre-reading phonological skills are efficient in reading novel items and, subsequently, in learning how to read and spell both regular and irregular items. In this way both lexical and sublexical processes will become efficient.

Apart from research emphasising the role of individual differences in phonological abilities, the role of instruction has also been noted. Seymour (1984) argued that the existence of a logographic stage in spelling and reading depends on the teaching method employed. Seymour and Elder (1986) found that when the teacher delayed teaching of phonics in her class for two years, students relied on logographic and not alphabetic skills.

Caravolas, Kessler, Hulme, and Snowling (2005a) carried out a longitudinal study of one hundred and fifty-two children in England. The first assessment was conducted at the end of Reception and the second in the middle of Year 1. From the initial sample they reported spellings of only 78 children whose vowel spellings were more than 10% accurate. The researchers calculated values for the stimuli including word and rime frequency, phoneme-grapheme probability (split into unconditional probability, such as the probability of a phoneme corresponding to a grapheme, e.g., all the different correspondences for the sound /ε/, and conditional probability, such as the probability of a phoneme corresponding to a grapheme taking into account the coda), canonical vowel spelling (e.g., *e* in *bed* is expected but not *ai* in *said*) and vowel grapheme simplicity (e.g., vowel single letter graphemes, such as *e* in *bed*, are easier to spell than digraphs or trigraphs, such as *ear* in *heart*). Children at both time points were assessed with 95 monosyllabic and monomorphemic words. The researchers initially carried out multiple regression analyses with criterion variable accuracy in spelling and predictor variables the stimulus-related values described above. They also conducted within-subjects regression analyses (binary logistic regression analyses) with criterion variable each child's spelling performance (a dichotomous variable of correct/incorrect responses). The researchers suggest that this type of analysis produces a more precise estimation of the significance of predictor variables. In both sets of analyses they found that the strongest stimulus-related predictor of spelling accuracy at both times was the consistency of vowels (unconditional probability) indicating a reliance on small units. Spelling accuracy was also significantly predicted by canonical vowel spelling and number of letters in the vowel spelling. Word frequency and rime frequency were only marginally associated, and rime frequency was not at all at the Time 2 assessment. They argued that novice spellers are sensitive to the statistical properties of the writing system almost from the beginning of instruction and that learning at least at this initial stage (at 5 years of age) is context-intependent. Therefore, the findings do not seem to support stage-like spelling development. Additionally, they do not agree with findings which suggest that children at the early stages of spelling acquisition rely on larger units such as rimes. By contrast it seems that small units (graphemes) are more salient at least for novice learners.

Similarly to Caravolas et al. (2005a), Spencer (1999) conducted a large scale study with typical and atypical spellers in Years 2 to 6 (ages 7 to 11 years), with a total sample of 236 students. Children were assessed with 40 items used also in the 1996 School Curriculum and Assessment Authority (SCAA) national survey. The stimulus-related variables used in the study were word length, phoneticity (the proportion of all the representations calculated for each phoneme, e.g., the grapheme <e> is found in 90% of cases whereas the grapheme <ai> is only found in 0.6% of the cases), word frequency and the probability value (percentage correct scores for each spelt item from the national survey conducted by the School Curriculum and Assessment Authority (1996) was converted to a probability value used in the regression model). Particularly, phoneticity relates to the ability of a learner to acquire the variety of phonetic representations and be able to spell each item with the correct spelling pattern among other possible candidates. Phoneticity was calculated using the 7, 000 most common words from the Lancaster-Oslo-Bergen (LOB) Corpus (Hoflan & Johansson, 1982). Spencer found that stimulus-related variables of frequency, number of phonemes and phoneticity exert a significant influence on children's spelling performance. Particularly Spemcer found evidence that word frequency is not a focal variable at age 7 but its influence begins after age 8. Word length was also found to exert a significant influence on children's single word spelling and this was evident even from age seven (r=-.81, p<.01). Finally the effect of unusual forms of phonemic representation was highly significant for children's spellings throughout the years, even when word length and frequency were controlled (r=.62, p<.0001). These results agree with Caravolas et al (2005a) findings presented above and with the significance of the transparency of the graphemes for accurate spelling.

A limitation of this study (Spencer 1999) was that the spelling test came from a national survey so word frequency could not be controlled effectively. Therefore

Spencer (2007) carried out a new study with 207 pupils attending Years 2 to 6 investigating the predictive validity of stimulus-related variables on spelling accuracy. In this study stimuli were the 150 most frequent items from British adult print materials (Hofland & Johansson, 1982). From the initial spelling list only 120 items were considered suitable for analyses. The stimulus-related variables included in the analyses were word length (calculated according to the graphemic and phonemic length), word frequency, number of complex graphemes in a word and least transparent phonographeme probability. Phonographeme frequency referred to the probability of a phoneme corresponding to a particular grapheme in the language. Phoneme-grapheme correspondences vary in probability, for instance the phoneme /or/ is found in 87 English words, though with the spelling <au> only once. Thus, the /or/ -> <au> correspondence has a very low probability of 1 out of 87. Spencer carried out correlation and regression analyses and found that transparency and complexity predicted spelling accuracy. Spencer reported that phonetic difference (the difference between the number of letters and phonemes in a word (such as the word *lamb,* four graphemes but three phonemes) was the strongest predictor. He suggested that this provides evidence of serial processing. He based his suggestion on the high correlation observed between phonographeme transparency and complexity of a word. This high correlation can also potentially explain the whammy effect observed for reading time reported by Rastle and Coltheart (1998)[1] in adults. Cossu, Gugliotta, and Marshall (1995) for reading and spelling in the transparent orthography, Italian, also found that double consonants yielded a significant number of errors in spelling (76% of the total errors) and in reading (36% of the total errors made). Another significant finding from Spencer's study was that word length affected spelling via the mediation of phonographeme complexity. This result corresponds with Weekes' (1997) findings that it is difficult to disentangle the unique contribution of stimulus-related variables such as word length due to high correlations with other variables. Findings from Caravolas et al. and Spencer's studies are opposed to Frith's (1980) notion that graphotactic knowledge emerges late in development and are in favor of dual route models which suggest that

[1] Evidence which favours serial processing within the sublexical/assembled procedure derives from work by Rastle and Coltheart (1998). They demonstrated that words with fewer graphemes are processed more slowly than words with more graphemes (e.g., <church> which has three graphemes and six letters is read more slowly than <splint> which has six graphemes and six letters). Their explanation was that a multi-letter grapheme, such as <ph> would activate first the phoneme /p/ then the phoneme /h/ and only afterwards the appropriate phoneme /f/. This effect, according to Rastle and Coltheart, provides support for a sequential non-lexical process that is incorporated in the DRC model and not for parallel processing that is part of single route computational models.

both lexically and sublexically related variables are significant for accurate spelling from the beginning of literacy instruction.

Case studies and cross-linguistic comparisons

Evidence against developmental stages of reading and spelling and in favour of a model in which lexical and sublexical processes develop in tandem also comes from case study reports. Howard and Best (1997) and Stothard, Snowling, and Hulme (1996) presented two case studies of adults whose non-word reading was impaired, but who, nevertheless, learned to read and spell at a competent level, apparently skipping the alphabetic stage. In a similar vein, Holm and Dodd (1996) showed that students from Hong Kong learned to read and spell in English without developed phonological skills. Thus, findings do not always support developmental stage theories (see for detailed description of the aforementioned study page 52).

Research in alphabetic scripts with more transparent orthographies than English, such as Greek, does not favour stage theories of spelling development. Children seem to proceed more quickly in the full alphabetic stage of spelling in comparison to their English peers; as children mainly produce phonologically-appropriate errors and this is found not only for typically developing spellers (see for example Loizidou-Ieridou, Masterson, & Hanley, 2009; Porpodas, 1991), but also for atypically developing ones (see for example, Nikolopoulos et al. 2003; Porpodas, 1991).

Porpodas (1991) investigated longitudinally 46 children divided into two different groups of 23 children. The one group had good segmentation skills according to syllable and phoneme awareness tasks and the other group had poor skills. Children were assessed at three time points. They were assessed at the beginning of Grade 1 (in the Greek school context children at this time do not possess reading and spelling skills), so according to the researcher children were assessed only on syllable and segmentation ability which included both real words and nonwords. At the end of Grade 1 and 2 children were assessed in spelling and reading of real words and nonwords. The spelling test consisted of 60 items (30 of them were orthographically regular and 30 were orthographically irregular). The items included in each category did not differ in frequency or word length. Porpodas found that both poor and good segmenters made a preponderance of phonologically appropriate spelling errors and that they were more accurate in spelling regular than irregular words. The results indicate that both groups of children do not employ a logographic strategy in spelling and this is due to the orthographic transparency of the language. This makes Porpodas to conclude that the phonological factor is more prominent in spelling Greek at least at the first years of literacy acquisition.

Similar conclusion was reached by Loizidou-Ieridou et al. (2009). They investigated the factors affecting spelling in 150 six- to- 11-year-old Greek spellers in a cross-sectional study. Children were assessed with 40 real words (split into 20 orthographically regular and 20 irregular words) and 40 nonwords. Real words were matched in terms of frequency and number of letters and nonwords in terms of number of letters. The researchers conducted by subjects and by items ANOVAS on the percentage error rates. The stimulus variables they included in the analyses were frequency and regularity of words and number of letters in a word. The effect of all three variables was significant. Based on finding strong spelling regularity effects (regular words were in general less error prone than irregular words) the researchers argued that the younger pupils relied on sublexical procedures. Qualitative analysis of spelling errors produced by students in all grades revealed that the majority of these were phonologically plausible, providing further support for reliance on sublexical processes. Older children appeared to utilize both lexical and sublexical processes, as both printed word frequency and word length, as well as regularity, affected spelling performance in the later grades.

Qualitative analysis of children's misspellings

According to Treiman and Cassar (1997), stage theories underestimate young children's abilities and conceptualize spelling development in a simplistic way. Although stage theories suggest that children rely heavily on letter names, Treiman (1994) demonstrated that the phonological characteristics of letter names and not letter names per se, influence children's spellings. Particularly, she found that children may more often use letter names for /r/ or /l/ but not so frequently for other phonemes. Treiman suggested that /r/ usage may derive from its postvocalic properties. The same conclusion was reached by Reece and Treiman (2001) who examined the stressed syllabic /r/ and letter-name vowels in the spellings of 35 first graders. The authors concluded that stage theories fail to capture the fine-grained picture of children's spelling development, and they overlook the fact that children's print exposure may lead them to produce conventional spellings at an earlier phase of development.

The other point Treiman and Cassar (1997) questioned is the notion shared by stage theories that children at the phonetic stage do not have orthographic knowledge. Treiman (1993c) categorized 6000 spellings of 43 first-graders into four groups: the first contained correct spellings, the second orthographically legal spellings, the third orthographically illegal spellings and the fourth omissions. She found that pupils, early in their spelling development, possess some orthographic knowledge. Specifically, they showed morphological awareness, for example, the flap sound in the word <dirt> and <dirty> was represented with a <t> and not with a <d>. Children showed sensitivity to letter sequences and to what is legal for print. The latter was shown through an orthographic constraint test where the pupils were more likely to choose the legal non-word than the illegal one. Hayes, Treiman, and Kessler (2006) found that second graders used graphotactic information when spelling initial and final consonants and not only phonological information as opposed to what is proposed in Frith's stage theory.

According to Varnhagen, McCallum, and Burstow (1997) stage models do not adequately describe spelling development. They conducted a study with 272 native English speakers addressing the split digraph rule and the regularly affixed past tense. They analyzed samples of written discourse produced by pupils in first to sixth grade and found that they could not assign children's spelling errors to a particular stage. Moreover, they found that a particular strategy may be used by children in different stages and concluded that a progressive developmental pattern could not be determined. They argue that children's spellings development could be conceptualized by the "overlapping waves model" proposed by Rittle-Johnson and Siegler (1999). They used a trial-by-trial analysis of spelling strategies in two conditions; in the first, children were asked to spell words rapidly so that use of strategic knowledge would not be allowed; in the second, children could spell at their own pace and use of strategies was allowed. Researchers found that, in contrast to stage models, spelling strategies were used by all children and that age did not affect the strategy used.

Interactive analogy model of spelling, Goswami (1993)

Goswami (1993) asserts in her interactive analogy model that the phonological and orthographic skills children possess interact throughout their literacy development and that a strategy of "analogy" helps them spell and read novel words. In Goswami's (1993) theory the phonological knowledge of rimes and on-sets which children use when spelling new words is significant and this knowledge facilitates reading skill

(Bradley & Bryant, 1983; Goswami & Bryant, 1990) and precedes phoneme awareness (Goswami, 1993; Goswami & Bryant 1990; Treiman, 1985). In a training study conducted by White and Cunningham (1990) the researchers found significantly better performance in decoding and comprehension for analogy classrooms compared to the control ones. Similarly, support that rime awareness predicts reading independently from phoneme awareness was shown in Bryant et al.'s (1990) longitudinal study. Researchers assessed 65 children when they were 4 years-old in phonological ability tasks (such as, rhyme, alliteration and phoneme detection) and found that preschool rhyme awareness predicted later reading skill even when they controlled for phoneme awareness but not later spelling skill. Similarly, Caravolas et al. (2005a) reported above, concluded that children as young as five years seem to rely more on small units when spelling rather than larger units (such as rimes).

Deavers and Brown (1997) also produced evidence that contradicted Goswami's views. They conducted two experiments with 60 children from Grade 1 to Grade 4 and fifteen undergraduate students. In the first experiment participants had to spell nonwords and the aim was to test whether participants use analogies for spelling. They used items with at least two friends (words with endings that sound and could be spelled the same) so that participants' spellings could be produced using analogy. The younger children relied more heavily on smaller units whereas older children and adults relied on larger units. A second experiment was based on Goswami's (1988) study, where a clue word was presented prior to reading each nonword. Forty children in Year 1, 2 and 3 were tested. Children made more use of analogies when the nonword was presented with the riming clue word rather than when it was presented in isolation. The researchers concluded that children are adaptive in their use of either small or large units depending on the task characteristics.

In agreement with this, Hayes et al. (2006) and Treiman et al. (2002) failed to find a significant onset and rime effect in spelling. Instead, novice spellers used information within the rime and information that crossed the onset-rime borders. Hayes et al. (2006) investigated 120 children attending Grades 2, 3, and 5 and thirty five college students. Researchers used a nonword spelling production task and a nonword choice task (participants had to choose between two nonwords the one that looked like a real word). Grapheme choices were determined by the following or preceding vowel, e.g., <Kent > is spelled with a <k> due to the vowel grapheme <e> and <cat> with a

<c> due to the <a> grapheme. They found that the vowel grapheme influenced the spelling both of the preceding and the following consonant.

Interim summary

Evidence for stage theories of spelling has not, in general, been supportive. The weight of evidence would currently appear to be in favor of DR models, and these were adopted for the present investigations. Properties of writing systems and languages and of the pupils themselves may determine the ease or the difficulty with which spelling is mastered. In the following section there is an examination of studies looking into reading and spelling processes in non-English writing systems. Transfer effects in bilingual spelling production, and cross-orthographic theories will be also presented.

2.5. Models/theories of printed word recognition and production in non-English speaking and bilingual participants

The DR model was developed based on empirical data from English speakers who were generally monolingual. Consequently there was need to investigate multiliterate and non-English populations and examine whether acquiring spelling in a second or a non-English language is different or the same as developing literacy in the dominant language or in English. In the following sections focus will be mainly on alphabetic languages that used DR framework for the investigations.

Within a DR model, reading and spelling development in orthographies more regular than English, such as Italian, Greek or Polish, could be explained. Scheerer (1987) argued that the DR model proposed by Coltheart (1978) could be a feasible model to explain lexical and sublexical processing independently of orthography if certain changes were made to it. For English, a deep orthography, as outlined above, two distinct types of dysgraphia are reported; phonological dysgraphia which involves difficulties with the sublexical procedure (e.g., Shallice, 1981) and surface dysgraphia, which involves difficulties with the sublexical procedure (e.g., Newcombe and Marshall 1985). The DR model can successfully explain the double dissociation. The question remaining is whether this model can be used in other orthographies as Scheerer argues.

According to the DR model of spelling (described earlier) two different routes a lexical one responsible for the retrieval of irregular and familiar words and a sublexical one responsible for novel word or nonword spelling are required. As different levels of word spelling are important for each route (smaller or larger units) this might indicate that different writing systems might show greater reliance on the one or the other route. For example, for the Greek language, Porpodas (1999) examined the number of phonologically plausible errors produced in spelling by poor readers and spellers, as well as reading rate. He found that poor readers exhibited slower reading and they made many phonologically plausible spelling errors, indicating greater reliance on the sublexical route. Similar findings were presented for German language by Landerl, Wimmer, and Frith (1997) who found that German dyslexic children were far more accurate in nonword spelling (89% accuracy) in comparison to their English counterparts (65% accuracy).

On the other hand written Chinese, a logographic writing system, might require greater reliance on whole word lexical processes as phonological encoding is less salient (see for example, the cross-linguistic studies described by Holm and Dodd, 1996, Chen et al., 2010 and Perfetti et al., 2007 presented later in the chapter). In support of the argument presented although phonological ability correlates significantly with English spelling performance (see for example Caravolas, Hulme, & Snowling, 2001 longitudinal study presented in section 3.2) this was not found to be the case for written Hebrew, a consonantal writing system, as Share and Levin (1999) found that morphological awareness significantly correlated with spelling skill. Prior to examining transfer effects in spelling processes, models of bilingual word recognition and production will be presented.

Printed word recognition and production in bilingual participants

Current research indicates that in bilinguals both languages are activated during reading and spelling (Dijkstra, 2005). Luelsdorff and Eyland (1991) proposed a model of bilingual spelling based on the DR model of monolingual spelling (Ellis & Young, 1988; Goodman & Caramazza, 1986) (See Figure 3). This model contains a lexical, a sublexical and a postlexical route (for oral and written spelling) for each language. The two linguistic codes can potentially interfere at the level of auditory input, at the phonological input lexicon and at the level of graphemic output and PGCs.

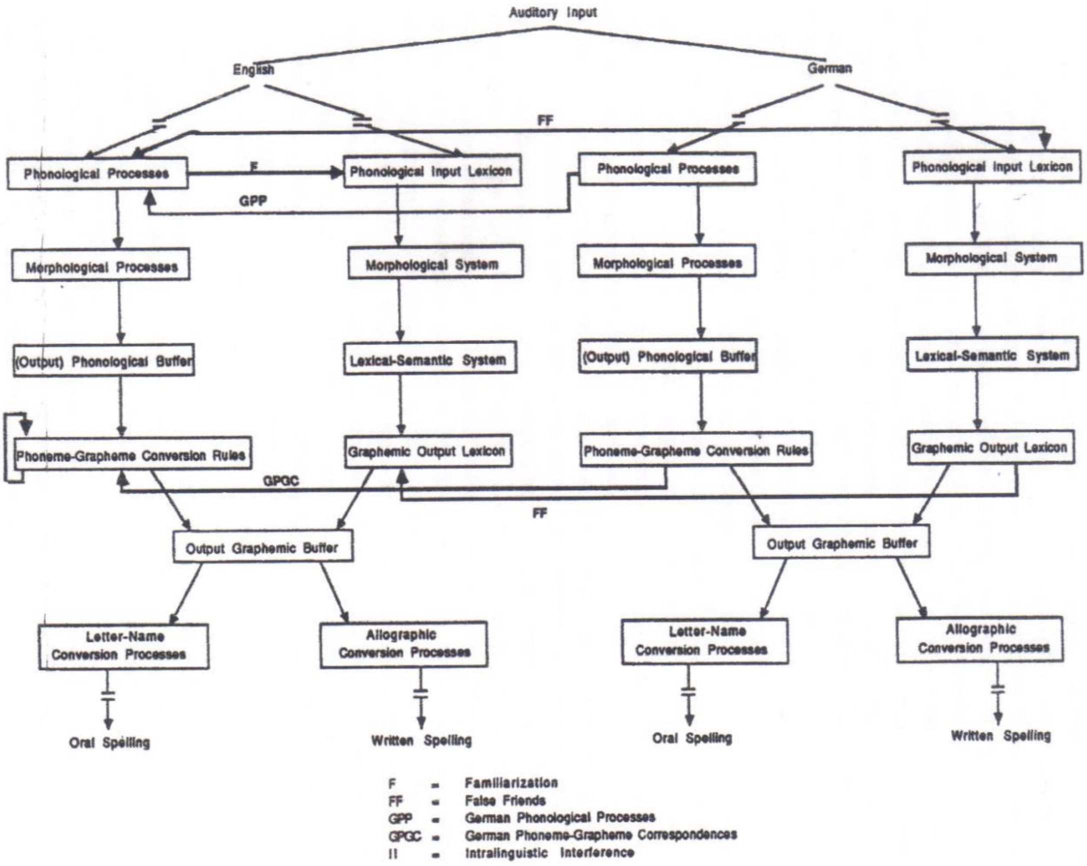


Figure 3: *A psycholinguistic model of emergent bilingual spelling proposed by Luelsdorff and Eyland (1991, pp. 183).*

The researchers claim that use of the monolingual spelling model for bilingual spelling production would lead to spelling English words as if they were German and vice versa, if L1 was English. Their bilingual model is based on qualitative analysis of the spelling errors of 23 emergent bilingual German- and English- speaking pupils in Grade 9. They used a list of 74 items for dictation, incorporating 'false friends' (words similar in meaning, phonology, orthography and morphology to the second language items, e.g., *allein* in German and *alone* in English). Non-false friends acted as control items. Spelling errors reflected interference of L1 (German) to L2 (English) at the level of phonological processing (for example, *schwan* -> SWAN), the level of PG conversion rules (for example, *from* -> VROM) and the level of orthographic processing (for example, *sommer* -> SUMMER). They found that false friends were more error-prone than non-false friends indicating a strong interlinguistic interference, as predicted by the model.

Luelsdorff and Eyland proposed a model that can effectively account for the emergent bilingual; consequently, fewer processes in common are suggested. Additionally, this model explains only spelling and not reading. The psycholinguistic model also deepens our conceptual understanding of bilingual spelling as it explains interference errors from first to second language. This is also the main difference between the monolingual DR model and Luelsdorff and Eyland's model. This chapter covered only DR models of spelling and not connectionist models, as DR theories were used to serve as the theoretical framework in the current studies. A constraint that needs to be acknowledged is that models of bilingual spelling are sparse, therefore data from monolingual participants is mainly used to justify the selection of the DR model as a theoretical framework for the current thesis. In general, bilingual models, apart from the one described by Luelsdorff and Eyland, have mainly focused on reading and the representation of words in the mental lexicon. Research looking at less proficient or emergent bilinguals is restricted. One aim of the present research was to increase our knowledge of spelling processes in emergent Greek-English bilinguals. Studies presented next also aimed to obtain evidence related to the flexibility and plasticity of the developing spelling system and differential use of lexical and sublexical processes depending on the transparency or opaqueness of the writing system.

2.5.1. Transfer effects in bilinguals' spelling performance

Usually second language learners are not blank slates in terms of literacy skill development. They bring oral language and literacy skills from their first language, which have been shown transfer to their second language. August and Shanahan (2006) conducted a large scale meta-analysis of research related to five topics associated with literacy development skills that transfer cross-linguistically. They concluded that first language literacy awareness – the ability to encode and decode one's language - transfers to the second language, and that this awareness is advantageous for English literacy acquisition. This corroborates the *interdependence hypothesis* (Cummins, 1979, 1981) which suggests that literacy skills in language one (henceforth: L1) will also be apparent in the second language (L2).

Cummins carried out pioneering research in the USA and Canada into language development in bilinguals. Since then evidence has been obtained from many cross linguistic studies with bilingual children. Sparks et al. (2008) in agreement with the *interdependence hypothesis* found that PA and spelling in L1 assessed in elementary Years were the best predictors of spelling in L2 assessed in secondary school. Xuereb (2009) investigated spelling, reading and PA skills in Maltese-English bilingual children in both their languages and found that performance on the Maltese PA task predicted reading and spelling in English. Similarly, De Sousa, Greenop, and Fry (2010) found that performance on a PA task in Zulu positively predicted spelling in the second language English in Zulu-English bilingual children. Sun-Alperin and Wang (2011) found that although PA (assessed by a phoneme elision task) in Spanish predicted English word reading and spelling in Spanish-English bilingual children, orthographic processing in Spanish did not predict English orthographic processing. The researchers concluded that although there are universal components in languages (such as PA) there are also language specific ones (such as orthographic knowledge). The latter is in agreement with the *script-dependent hypothesis* described next.

According to the *script–dependent hypothesis* (Geva & Siegel, 2000) "problems encountered in reading and spelling are attributed to the orthography used" (Abu-Rabia, 2001, pp. 442). For example, differences in script, such as letter <l> /l/ in English and the equivalent in Greek <Λ,λ> /l/, may negatively affect spelling of the particular grapheme by Greek- and English-speaking bilinguals. The *interdependence hypothesis* Cummins (1979) predicts that irrespective of characteristics of orthographies similar problems will be apparent in bilinguals' reading and spelling across languages, since there is a central processing deficit. Abu-Rabia (2001) in a study with Russian-English adult bilinguals did not find significant cross-linguistic association between performance in assessments of orthographic ability, such as recognizing letter combinations in nonwords in line, or not, with particpants' orthography (e.g., choice between filv and filk). These results support the *script-dependent hypothesis* whereby orthographic abilities are not transferred from one writing system to another. Alternatively, in the same study the researchers found a strong predictive relation between PA and spelling skills in L1 and L2 word reading, supporting the *interdependence hypothesis*. Researchers reconcile the apparently contradictory findings by arguing that aspects of literacy, such as, phonological ability and working memory are universal but others, such as orthographic ability (described above), may be language specific and hinder language transfer effects.

Koda and Zehler (2008) also argued that less interrelation will be observed when the two writing systems are different than when they share common characteristics. In a study conducted with emerging Russian-Hebrew-and English-speaking triliterates and biliterates, Kahn-Horwitz, Schwartz, and Share (2011) found that English language orthography was easily acquired when phonemes were shared between orthographies, for example the phonemes /tʃ/ and /ʃ/ which also existed in Russian, or the phoneme /ʃ/ which also existed in Hebrew. When a phoneme and its corresponding grapheme were alien in L1 orthography their acquisition was challenging for the emergent bilinguals. The researchers, for example, examined the split digraph rule which is not represented in Russian or Hebrew and reported that acquisition was challenging even after three years of EAL instruction. On the contrary, acquisition of consonant singletons, even when they were novel among the orthographies, did not present too much difficulty for the children.

Holm and Dodd (1996) observed similar findings. They carried out a study with university students who were learning English as an additional language. Students were from the People's Republic of China, Hong Kong, Vietnam and Australia. The participants were assessed on PA, reading and spelling. Holm and Dodd found that Hong Kong students had relatively weak levels of PA, and were limited to visual analytic skills in order to read and spell English, as their performance in an auditory/ visual matching words task did not differ from the other groups' performance. On the other hand, students who possessed an alphabetic L1 did not have any difficulty in reading and spelling pseudowords. They concluded that strategies transfer from L1 to L2, as students with an alphabetic L1 relied on sublexical strategies and those with a logographic L1 adopted visual/whole word strategies.

Language transfer effects, in support of the *script-dependent hypothesis*, have been reported in other studies of different script languages, such as, for example, English and Mandarin. Liow and Lau (2006) observed differences in strategies used for English spelling between biliterate Mandarin-English and Malay-English speaking children. Mandarin-English speaking children, assessed in a forced-choice 'flaps spelling test' (e.g., children were asked to choose: *d* or *t* for *wa_er*), appeared to rely on visual analytic skills in order to spell in English, whilst the Malay-English speaking children appeared to rely on phonological skills. The authors concluded that this was due to the transparency of the Malay orthography.

In two studies, one cross-sectional and the other longitudinal, with Chinese and English bilingual and Chinese monolingual children in Grades 1 to 3, Chen et al. (2010) found that instruction in an alphabetic L2 facilitated PA in L1. They noted that a certain level of linguistic awareness in L2 should be possessed in order for positive transfer to be observed. Their study provides support to Cummins' (1976) *'threshold hypothesis'* which holds that "a threshold level of linguistic competence must be attained both in order to avoid cognitive disadvantages and allow the potentially beneficial aspects of bilingualism to influence his cognitive and academic functioning" (p. 3).

Figueredo (2006) carried out a review of 27 studies examining the development of spelling ability in EAL students. The review supported the notion that positive or negative transfer will take place depending on individual language characteristics. Positive transfer will occur when commonalities exist among orthographies (such as common letters) or strategies used, e.g., phonological or visual skills. Figueredo also reported, as noted earlier, that transfer across languages of literacy-related skills is evident from studies reporting cross-linguistic correlations, such as first language reading performance and PA being statistically associated with second language spelling ability. On the other hand, negative transfer will occur when, due to lack of competent L2 awareness, rules specific to L1 are generalized to L2. In the studies examined in the review, eight found positive transfer and three found negative transfer effects, and one study did not find any cross-linguistic effects.

Similarly, findings from Mumtaz and Humphreys' (2001, 2002) cross-linguistic studies indicate transfer of reading skills, depending on the characteristics of each orthography in which the children are more strongly literate. The particular study is presented although it assessed reading and not spelling as a major aim of the Study 2a and b in the current thesis aimed to find similar indices of transfer effect in spelling to the ones Mumtaz and Humphreys found in reading in two groups of bilingual Greek- and English-speaking children who differed in their Greek literacy ability but not in their English literacy ability. Mumtaz and Humphreys conducted a study with Urdu which has a transparent orthography. Children were English and Urdu speakers aged seven to eight years old. Mumtaz and Humphreys (2002) found that children with strong Urdu vocabulary relied on sublexical processes for reading in English. In comparison with the children with weaker Urdu vocabulary skills, they were more competent in PA tasks, at reading English regular words and nonwords, but they performed poorly in measures of visual memory and irregular word reading. By contrast, the children with weak Urdu vocabulary awareness were better in reading English irregular words and in tasks tapping visual memory, but they performed significantly lower on PA tasks and nonword reading.

Another cross-linguistic study by Perfetti et al. (2007) was also on reading but is included as it is relevant to Study 2a and 2b. It investigated transfer effects in spelling with typically developing adult participants. Perfetti et al. reviewed event-related potential and fMRI studies in an attempt to explain the cross-linguistic transfer effect among Chinese–English and English–Chinese bilinguals. This study provides evidence from event-related potential and fMRI studies of Chinese-English and Chinese L2 adult learners of the flexibility and plasticity of neural networks to successfully accommodate the new linguistic system. The researchers also suggested that Chinese second language learners in order to read Chinese recruit neural networks not essential for alphabetic reading, while English second language learners recruit neural networks used for Chinese reading also for English reading, especially those related with procedures of lexical/whole-word processing. This might occur as there are universal abilities, such as phonology and there are language specific ones, such as writing system. Therefore, they argue that Chinese-English bilinguals use Chinese-based strategies (lexical whole word recognition) to learn English but English-Chinese bilinguals cannot do the same when learning Chinese. In Figure 4 is provided a visual depiction of areas activated while viewing English words or Chinese characters by either native English speakers learning Chinese as a second language or Chinese speakers learning English as a second language, from Nelson et al. (2005).

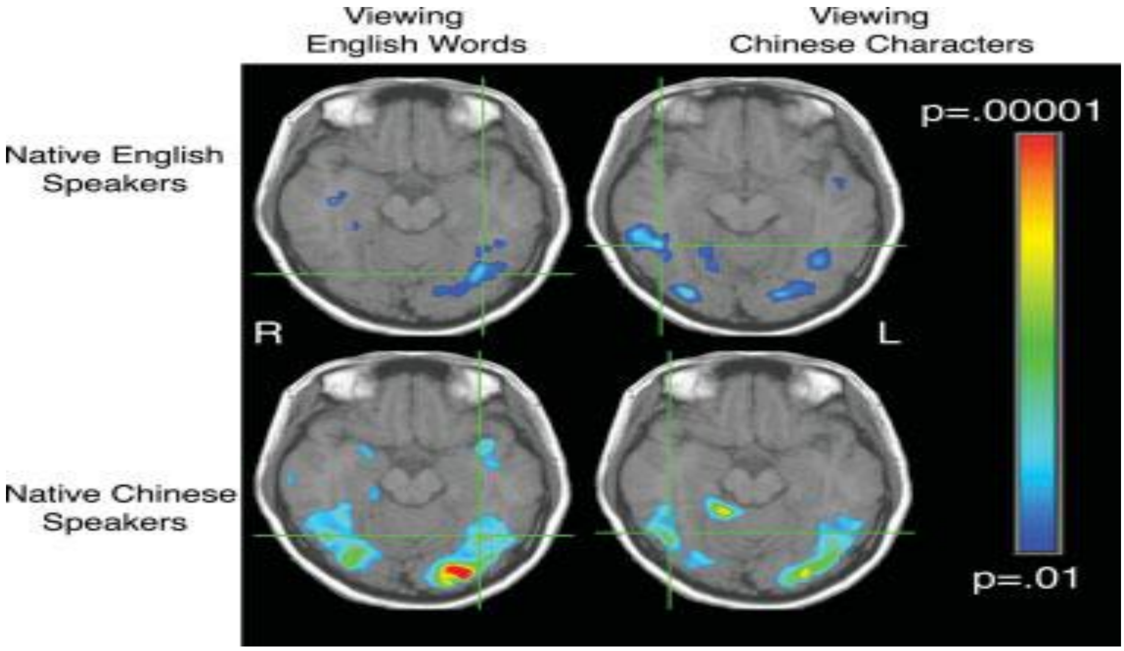


Figure 4: *Depiction of brain activation in bilingual Chinese-English and English-Chinese participants. Bilingual English -Chinese show a bilateral occipital and fusiform activation for Chinese and a standard alphabetic pattern for English. Chinese-English bilinguals show similar activation for both English and Chinese.*

2.5.1.1. *The Orthographic Depth Hypothesis*

Cross-orthographic studies have consistently shown that reading of words and pseudowords and PA develops rapidly in transparent orthographies in comparison to opaque ones (Spencer & Hanley, 2003; Seymour, Aro, & Erskine, 2003). Cross-orthographic research into spelling indicates that spelling in English is far more difficult than in more transparent orthographies such as French (Caravolas, Bruck, & Genesse, 2003). The transparency of the association between spelling and phonology and the opposite is not isomorphic between orthographies. There are shallow orthographies where phonemes are represented by graphemes in one-to-one correspondences and the same characterizes the grapheme-to-phoneme relation. However, there are also deep orthographies with non-isomorphic correspondences in both directions (graphemes-to-phonemes and via versa). According to this variance the "Orthographic Depth Hypothesis" (Katz & Frost, 1992) was developed, which states that the degree of transparency affects the processes used for reading.

Frost et al. (1987) demonstrated in a cross-linguistic study with Hebrew, English and Serbo-Croatian students that characteristics of orthography determine the use of phonological or lexical processing. Frost et al. (1987) argued that phonological information is not used by participants with deep orthographies as the phoneme-grapheme correspondences are not reliable. Evidence from printed word naming and lexical decision tasks was used. In the first experiment they found that lexically-related stimulus characteristics, such as printed word frequency, affected naming latencies in Hebrew and English but not in transparent Serbo-Croatian. In the second experiment, they found semantic priming effects for Hebrew, to a lesser degree for English, but not at all for Serbo-Croatian.

Figueredo (2006), reported in previous section, noted that differences in orthographic depth (Katz & Frost, 1992) may hinder the spelling performance of the biliterate, as transparency of L1 may lead to regularization errors with irregularly spelt words in L2. Thus, students with a transparent L1 may find the opaque nature of English orthography difficult to fathom. Figueredo also concluded that children whose L1 is more transparent than English possess stronger phonemic awareness. This awareness is transferred to English as well and is regarded as positive transfer (Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Da Fortuna & Siegel 1995; Abu-Rabia & Siegel 2002). However, different findings were reported by Loizou and Stuart (2003). They conducted a study with 68 children from Cyprus and England. Children formed four groups, two groups of bilingual Greek-English and English-Greek and two groups of monolingual Greek and English speakers. They found that a positive phonological ability (PA) transfer from L1 to L2 was evident only for the English (L1) to Greek (L2) sample. The researchers explained this result according to the bilingual enhancement effect which suggests that transfer will occur when the L2 is a phonologically simpler language in comparison to L1.

Frost (2005) in a review of the Orthographic Depth Hypothesis pointed out that two versions of the hypothesis exist. The first is the strong Orthographic Depth Hypothesis which states that in transparent orthographies only prelexical phonological processes are used in naming and for deep orthographies only lexical processing is employed. The strong view has been challenged by the results from several studies. See for example the study by Loizidou et al (2009), mentioned in section 2.4.1, which found that both lexical and sublexical stimulus-related variables affected spelling in Greek. A similar finding for reading was obtained by Zoccolotti et al. (2009). The researchers investigated stimulus-related variables including, frequency, number of letters in a word and lexicality, in reading of 503 Italian children attending first-to-eighth Grade.

Thus a version of the Orthographic Depth Hypothesis was developed which argues that both prelexical and lexical phonological and orthographic information is necessary for reading and spelling in any orthography. This is incorporated in the DRC model; this model argues that both processes are significant irrespective of orthographic depth, based on empirical evidence (see section 2.3). The research indicates that the depth of the orthography determines the reliance on each process (lexical or sublexical) as will be discussed next in section 2.5.1.2. Thus, in a shallow orthography, participants rely more, but not exclusively, on sublexical processes, whereas this cannot be the case for a deep orthography as sublexical PGCs are not reliable and both lexical and sublexical processes are important. In the next section variation in pace of literacy acquisition according to the transparency of the writing system is reviewed.

2.5.1.2. *Cross-linguistic variance in the acquisition of spelling skill*

Research suggests that the manifestation of literacy deficits varies according to the characteristics of writing systems, such that a phonological deficit might not be so profound in the case of transparent orthographies. Wimmer (1993) in a cross-sectional study with German-speaking dyslexic children (8, 9 and 10 years old) reported that the performance of dyslexic children in tasks tapping phonological processing was high and that dyslexic children mainly showed general processing speed impairment (manifested in long reading latencies and slow rapid automatized naming). Children's nonword spelling was significantly accurate even for the dyslexic/dysgraphic groups. The errors became fewer as the children grew older and there were no refusal errors. Additionally errors were close to the target word and mainly occurred on longer multisyllabic nonwords (e.g. *nosti*-> NOSPI). Similar findings were reported by Landerl and Wimmer (2000) who reported that German dyslexics made more phonologically plausible misspellings than their English peers. Additionally, Porpodas (1991) found similar results for Greek typical and atypical spellers (see section 2.4.1.)

Caravolas and Volin (2001) critiqued Wimmer and colleagues' studies that the criteria adopted for categorizing misspellings in phonologically plausible are lenient. Caravolas and Volin demonstrated that phonological impairment is not transient in dysgraphic children learning more transparent orthographies than English, such as Czech. The researchers collected data from 43 dysgraphic children (mean age 9-to-12 years), 43 age matched control children and 43 spelling age matched control children. Children were assessed in reading and spelling and their spelling errors were categorized into phonologically plausible and the opposite and performance was contrasted with that of the two different control groups. The researchers concluded the dysgraphic children produced approximately 19% of phonologically plausible errors when their peers made only 4%. The researchers justify the discrepancy due to differences in tasks employed or differences in error categorization. The researchers suggest that after all maybe orthographic depth is not a significant determinant in overcoming spelling difficulties in more transparent orthographies and that the characteristics of dysgraphia do not significantly differ among transparent and opaque orthographies. Caravolas, Volin, and Hulme (2005b) in a subsequent cross-linguistic study investigating the association between PA and reading and spelling in a transparent orthography Czech and an opaque one, English with typical and atypical 9-year-old spellers found that phonological ability predicted spelling of both English and Czech. Caravolas et al. in relation to the performance of the dysgraphic children in the two orthographies reported that dyslexic children showed similar results in phoneme deletion and spoonerisms tasks. This indicated that children with dysgraphia in more transparent orthographies have phoneme awareness difficulties which do not seem to be ameliorated by orthographic characteristics. The researchers showed the need for more difficult or timed PA tasks for readers of transparent orthographies, in order to detect an effect of phonological ability on spelling and reading skill. Similar argument was posited by Nikolopoulos et al (2003) for Greek dysgraphic/dyslexic children.

Another hypothesis developed in close relation to the aforementioned is the Grain Size Hypothesis. This did not try to provide an answer to the question of whether spelling and reading is a phonological process for transparent orthographies and a lexical process for opaque ones, which was the aim of the Orthographic Depth Hypothesis. The Grain-Size hypothesis focuses on the size of unit that readers of different orthographies employ in order to achieve reading and spelling. This hypothesis will be covered next.

2.5.2. The grain-size hypothesis

Ziegler and Goswami (2005, 2006) proposed the *'grain size' theory*, whereby differences in orthographic transparency result in developing reliance on different sublexical units. For example, English is highly inconsistent at the small grain level (single graphemes and clusters, as discussed in section 2.2.) and it is argued that this can lead to dependence on larger units, such as onsets and rimes, which are less inconsistent

(Treiman et al., 1995), while this will not be the case for consistent orthographies, such as Greek and German. Although there is considerable research (see section 2.4.1 for a review) suggesting that onset and rime is not a significant predictor of English spelling and reading there are also other studies claiming the opposite.

For Greek, Harris and Giannouli (1999) and Aidinis and Nunes (2001) reported that Greek children attending kindergarten show signs of syllabic awareness but not phonemic in phonological awareness tasks. However, as soon as formal reading and spelling instruction begins at Grade 1, pupils' phonemic awareness is rapidly developed and at the end of Grade 1 both tasks reach ceiling (Tafa & Manolitsis, 2008; Nikolopoulos et al. 2006). This is unlike the case for English-speaking children (see section 3.2 and study conducted by Caravolas et al., 2001). Tafa and Manolitsis (2008), in a five year longitudinal study looking at the performance of 13 precocious Greek readers and 12 non-precocious readers from kindergarten up to Grade 4 and investigating reading, spelling and PA, reported that the transparency of orthography forces children to rely on smaller grains from a younger age as the study did not find a significant relationship between rime awareness and early reading and spelling as has been reported for English-speaking children (Goswami, 1993, see for example section 2.4.1.) .

2.6. DR models as a framework for spelling performance in Greek and English monolingual and bilingual schoolchildren

Different theories have been proposed to try to explain monolingual and bilingual children's spelling development. Research covered in previous sections has indicated that the processes a child employs for spelling are flexible and that both lexical and sublexical skills are employed in order to achieve accurate spelling. The degree of reliance on procedures appears to depend on the characteristics of the orthography, of the task, of the instruction received and on the age of the participant. Therefore a generic DR model of spelling (Barry, 1994) and reading (Coltheart et al., 2001) which proposes the existence of lexical and sublexical processes (independent but also with the ability to interact), capable of describing the flexible nature of spelling acquisition, is considered to be the most appropriate theoretical framework to guide the research in the current thesis. The next section covers factors that affect spelling, starting with child-related and going on to stimulus-related variables. The aim of examining the influence of these factors in the research was to increase our understanding of the processes involved in spelling of monolingual and bilingual English and Greek-speaking children, and the DR model was the lense through which the findings were viewed and interpreted.

Chapter 3

3. Effects of child and stimulus characteristics on spelling accuracy

3.1. Introduction

In this section child-related variables that have been found to be associated with spelling skill in biliterate and monoliterate children are discussed. These variables are phonological ability, verbal and visual short-term memory, rapid automatized naming, receptive vocabulary, morphological awareness and print exposure. It has long been held that the core deficit in dyslexia/dysgraphia relates to phonological processing and that phonological processing is a strong predictor of reading and spelling; particularly referring to the ability to manipulate speech sounds, to perform tasks tapping verbal short-term memory (such as digit span and nonword repetition) and lexical retrieval (such as rapid automatized naming) (for a comprehensive account see Wagner & Torgesen, 1987; Snowling, 2001; Snowling & Rack, 1991; Vellutino et al., 2004; Wolf & Bowers, 1999; Papadopoulos, Georgiou, & Kendeou, 2009; Georgiou et al., 2010). A child's reading and spelling performance, based on the research evidence, might be related to all of these or just some of them. However, the causal relationship between phonological processing and reading and spelling attainment has been questioned, as we will see in the next section, and has come to be challenged in recent years (Vidyasagar & Pammer, 2010). Thus, in the current thesis other variables apart from phonological processing were examined in relation to spelling performance of bilingual and monolingual children.

3.2. Child-related variables associated with printed word production

Phonological awareness (PA)

Research on phonological ability (the ability to identify and manipulate speech sounds) has shown that it appears to play an important role in reading and spelling development, not only for English (Caravolas et al., 2005b; Ehri et al., 2001; Stuart, 2004; Stuart & Masterson, 1992), but also for other alphabetic languages (Caravolas et al., 2005b; Porpodas, 1999) (see section 2.5 respectively for a review). Phonological ability has also been found to be a longitudinal predictor of spelling in deep orthographies such as English (Caravolas et al., 2001) but also transparent ones (Lervag & Hulme, 2010; Nikolopoulos et al., 2006). Ehri et al. (2001) conducted a quantitative meta-analysis of 52 research papers investigating the effectiveness of phonological ability for learning to read and spell. They found that PA is a statistically significant predictor of reading (mean effect size (d: 0.53) and spelling (d: 0.59). However, they assert that PA is important for those who have not developed it yet and teaching must be combined with letter-sound instruction. This was also demonstrated in several intervention studies (for example, Hatcher et al., 2002; Stuart, 2004).

The significance of PA and sublexical skills for orthographic learning was also proposed in the *self-teaching hypothesis* (Share, 1999). Share, conducted four experiments with second grade Hebrew-speaking TD readers. In the first experiment children read nonwords embedded in a passage consisting of 94 to 170 words. The results indicated that sublexical skill allows the child to develop orthographic representations significant for sight word recognition. In the second experiment Share tried to falsify the results of the first experiment using a lexical decision task. The result was consistent with the first experiment indicating the significance of sublexical skills and not of mere exposure to the words. In the third experiment he demonstrated that other factors such as exposure duration and presentation of target stimuli did not affect acquisition of novel items. In the fourth experiment he used familiar nonalphabetic characters (e.g., +,=,$ etc.) in order to demonstrate that it is phonology that is the determinant and not visual exposure. Share critiques Parallel Distributed Processing Models as not able to address this inherent ability to recode phonemes and gain orthographic knowledge. However, he acknowledges that Zorzi, Houghton, and Butterworth (1998) addressed the lack by including a sublexical route.

PA is also important for Greek written language acquisition (Porpodas 1991; 1999, see also section 2.4.1 & 2.5). Mouzaki, Protopapas, and Tsantoula (2008) conducted a longitudinal study with 55 Greek-speaking students. The first data were collected at the end of Kindergarten and the second in the middle of first Grade. They found a high correlation between PA and reading and spelling performance. In agreement with the findings of Porpodas (1999) they found poorer spelling performance in the pupils with weak phonemic awareness. A limitation of Mouzaki et al.'s study is that pupils were recruited from a single private school, which may not have been representative of the population. However, a strong correlation between PA and reading and spelling was also reported by Kotoulas (2004). He conducted a study with 280 Greek-speaking pupils with and without learning difficulties. The children were recruited from 40 different schools and were attending Grade 1 to 6. They were tested on 10 different PA tasks, on reading words and non-words and spelling performance. Results confirmed that children with reading difficulties had low PA performance and phonological ability correlated significantly with both measures of spelling used (r=.81 and r=.78). A limitation though of the presented study is that correlations were performed with the whole sample and therefore we can not be sure if there would be differences in case the correlations were conducted per Grade. Another significant finding is that performance of the TD children approaches ceiling performance after the second Grade and it is almost 100% accurate at 6th Grade. However, this was not the case for RD children whose phonological ability was considerably lower in comparison to the performance of typically developing children (for example first Grade children scored approximately 40% correct whereas TD children at the same age scored 75% correct in PA tasks). Therefore findings corroborate Caravolas et al.'s (2005b) argument that PA is a significant determinant of spelling disabled children who learn a transparent orthography.

In a longitudinal study, Tafa and Manolitsis (2008) found that PA is a significant factor only early in literacy acquisition and the researchers claim that this was also found in other Greek studies looking into PA (Manolitsis, 2004; Porpodas, 1992, 2001) and in other transparent orthographies (de Jong and van der Leij, 1999; Wimmer et al., 1991). However, in agreement with Ziegler et al. (2010a) the predictive power of PA could be relatively weak in Tafa and Manolitsis's study as children's scores approached ceiling after Grade 1. In the same study, children's spelling appeared to change from correct phonological spelling to orthographic spelling based on qualitative analysis conducted at the end of Grade 1 for the precocious readers and at the end of Grade 2 for the non-precocious readers.

In a study with 1,265 children in Grade 2, speaking five languages with diverse orthographies (Finnish, Hungarian, Dutch, Portuguese and French) Ziegler et al. (2010a) found that the significance of PA as an indicator of literacy difficulties depends on the transparency of the orthography. It was found to be more significantly related to reading skill in opaque orthographies than transparent ones. Ziegler at al. concluded that PA is more significant at early grades or in pre-literate children than in older children in transparent orthographies as performance then approaches ceiling. The researchers also noted that the rapid naming is found in several studies with transparent orthographies to be a strong predictor of reading skill after PA is not sensitive enough or it has reached ceiling. However, this study assessed only reading skill and not spelling.

As noted earlier, several studies conducted in transparent orthographies indicate that a consequence of learning to read and spell in these writing systems is rapid development of PA skills and grapheme–phoneme knowledge (see section 2.5). Bergmann and Wimmer (2008) claim that in a transparent orthography, even for dyslexic children, the child's phonological impairment will be moderate and they will achieve ceiling on less demanding tasks. The researchers conducted a study with two groups of 20 dyslexic and 20 non-dyslexic readers from 15 to 48 years old. They found that dyslexics' phonological processing was not impaired in comparison with controls' performance (the between group error rate difference for phonological tasks was small - 6.7%), however their lexical processing seemed to be deficient, as assessed by an orthographic lexical decision task (the between group error rate difference was 27%). The main characteristics of the dyslexics were reading speed and spelling impairment, suggesting according to the researchers that phonological awareness is not deficient in a transparent orthography due to the consistent grapheme-phoneme correspondences. In agreement with these findings, similar results were reported in a longitudinal study of Finnish speakers (Holopainen, Ahonen, & Lyytinen, 2001), and of Greek participants (Porpodas, 1999), described earlier (see section 2.5).

In contrast to Bergmann and Wimmer's finding regarding the role of PA, Caravolas et al. (2005b, reported in section 2.5.1.2.) and Kotoulas (2004) found that PA was a strong predictor of reading and spelling in transparent orthographies. The results may be attributed to the demanding PA tasks that Caravolas et al. (2005b) used.

Similarly, Nikolopoulos et al. (2006), in a longitudinal study with Greek children, found that PA was a predictor of reading at Time 1 (seven- and nine-year-olds) and for spelling at both Time 1 and Time 2 (eight- and ten-year-olds). In another cross-linguistic study Smythe et al. (2008) examined five diverse languages (Arabic, Chinese, English, Hungarian & Portuguese) and investigated cognitive factors that affect reading and spelling such as PA, rapid naming, visual memory and sound discrimination. The authors also concluded that the significance of PA is dependent on the writing system and the orthographic transparency. For spelling in Chinese, the most significant predictor was visual processing and sound discrimination, while PA, phonological memory and decoding were the most significant predictors for English, Arabic and Hungarian spelling. Rapid naming was a predictor of reading accuracy of Chinese, English and Portuguese, but PA was a predictor of reading for all five languages.

In a cross-linguistic study with 50 six-year-old Greek participants, Masterson et al. (2008) investigated the predictive power of child- and stimulus-related variables for single-word spelling. They observed a preponderance of phonologically appropriate spelling errors, and that performance in a PA task significantly predicted spelling performance. The researchers found a different pattern when they investigated six-year-old English children's spelling. These children's spelling performance was predicted by scores on a visual memory task, in addition to scores in a PA task.

Although, studies indicated that there is a strong relation between PA and reading and spelling, Castles and Coltheart (2004) argued that one cannot be certain that PA is a causal determinant of success in reading. This is because in training studies researchers have never solely trained PA, and there is not robust evidence that PA training led to spelling and reading improvement, and specifically nonword spelling and reading. Finally, they argued that only training in children with no literacy skills would be a robust indicator of the effectiveness of PA intervention. Hulme et al. (2005) responded to the above argument by claiming that the relationship between reading, spelling and PA should be conceptualized as a multidimensional process, to which other factors could also contribute (such as, print awareness, letter knowledge etc.).

Interim Summary

PA appears to play an important role in the acquisition of spelling and reading. PA has also been found to be important for bilinguals, and PA in L1 predicts reading and spelling in L2. As a consequence it is considered to be a universal factor underlying progress in literacy ability. Siegel (2007) argues that PA is the core deficit for spelling and reading difficulties in different orthographies. However, there now exists abundant research evidence that PA is not the only factor predicting spelling ability; therefore the current thesis will also investigate other factors found to be associated with spelling of monolingual and bilingual children. Next, evidence related with phonological short-term memory will be examined.

Phonological short-term memory (STM)

According to Gathercole (2006) verbal STM is important for spelling since failure in the storage or retrieval of a word will result in reading or spelling mistakes. Gathercole and Baddeley (1993) provided an account of working memory (presented in Figure 5).

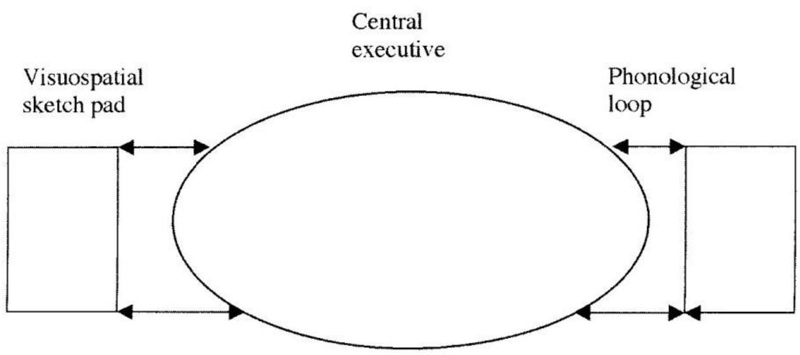


Figure 5: *Model of Working Memory (Gathercole & Baddeley, 1993, pp. 4)*

Working memory was said to consist of the Central Executive and two slave systems: the visuospatial sketch pad, which temporarily stores visual and spatial input and the articulatory loop, which temporarily stores verbal input. The main difference between STM and working memory is that the first refers to retaining information, whilst the second refers to retaining and simultaneously manipulating information.

Passenger, Stuart, and Terrell (2000) carried out an 18-month longitudinal study assessing 80 pupils for PA, phonological STM, reading, spelling and general ability. They found that performance in a measure of phonological STM was significantly correlated with scores for non-word reading and spelling. In agreement with this, Leather and Henry (1994) also found that phonological STM correlates with reading and spelling. They assessed 7-year-old children in PA, complex and simple memory tasks and found that complex memory tasks correlated strongly with reading and spelling accuracy.

Similarly, phonological STM was found to be important for spelling and reading for Greek pupils as well. Greek consists of long multisyllabic words which will place a burden on reading and spelling processes in novice readers until these become fast and automatic skills. Masterson et al. (2008) in four different studies (see previous section on PA) found that the strongest predictors of spelling for young Greek children were PA and verbal STM (as assessed by a digit span task). Additionally, Mouzaki, Spantidakis, and Vamvoukas (2007), investigated literacy skills in 73 Grade 1 and 2 Greek speaking children and found that PA and visual (as assessed by a visual short-term memory task, developed by Vamvoukas (2004)) and verbal short-term memory (as assessed by a digit span task) differed significantly between poor and good readers and spellers when the researchers controlled for age and verbal ability.

Phonological short-term memory has been found to predict spelling performance in other transparent orthographies. In a longitudinal study with Norwegian (a transparent orthography) children Lervag and Hulme (2010) found that phonological short-term memory (as assessed by four different verbal span tasks with colours, digits, letters and objects) is a strong predictor of early spelling skill. Steinbrink and Klatte (2007) also found that phonological STM was poor in a group of 14 German speaking poor readers and spellers. Consequently, phonological STM seems to be a significant child-related variable for spelling in opaque and transparent scripts.

Rapid automatised naming

Despite research evidence indicating that rapid automatized naming (henceforth: RAN) predicts reading (accuracy and speed) independently from PA (e.g., Bowers & Swannson, 1991; Hagiliassis, Pratt, & Johnston, 2006; Powel et al., 2009; Swanson et al., 2003), there is little agreement as to what is the underlying cognitive skill determining this relationship, or whether indeed the RAN component is independent of phonological processing. Studies conducted, as we will see next, indicate that rapid naming is strongly related with reading speed for transparent orthographies (Landerl & Wimmer, 2008; Moll et al., 2009; Moll & Landerl, 2009; Di Filippo et al., 2005) and opaque orthographies (Morfidi et al., 2007) and in non-alphabetic orthographies such as

Chinese (e.g., Georgiou et al., 2008a&b, 2009). Although an association has been demonstrated for reading speed and RAN, things are not so clear cut when it comes to spelling.

The independence and significance of RAN for reading speed was reported in a factorial-analytic study conducted by Hagiliassis et al. (2006) with 177 English-speaking children attending Grades 3 to 5. The researchers found that alphanumeric and colour RAN performance loaded on a single factor that they named *general processing speed* (.90-.86). The researchers concluded that phonological ability and nonword reading factors load on a different variable than the one that RAN tasks load on; supporting the notion that RAN is independent from phonological processing. Additionally, Powell et al. (2007) examined RAN in 1010 7 to 10 year old children in the UK. The researchers conducted structural equation modeling and they could not find a good fit by combining RAN and phonological processing.

Turning now to spelling skill, an association between RAN and spelling recognition but not spelling to dictation was found by Sunseth and Bowers (2002b) in a subsample of children with a naming speed deficit. A similar association was not found for children with a phonological deficit or in a double deficit group. Pennington et al. (2001) found that PA is more strongly associated with English spelling than RAN. In a recent study Stainthorp, Powell and Stuart (2013) investigated the association between spelling performance and RAN in 8;05 years children. They found that RAN made a significant contribution in spelling performance above the association between PA and spelling. Further investigation of a group of poor spellers with a single 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 a clear association between RAN and irregular word spelling. The researchers justify the latter by arguing that RAN might be associated with the child's ability to establish a good quality of orthographic representations in the mental lexicon.

For Greek, Nikolopoulos et al. (2006) failed to find that RAN was a longitudinal predictor of spelling performance (see also section 3.2 of the current thesis). In agreement, Moll et al. (2009), in a large study with 1,248 German-speaking children examining the association between RAN, PA, nonword reading and orthographic processing by conducting hierarchical regression analyses, concluded that RAN predicted word and non-word reading while phonological ability predicted only spelling.

In a subsequent study Moll and Landerl (2009) investigated a sample of 2,029 German speaking primary school children (Grades 2-4) split into four groups: 6% were poor readers but good spellers, 7% were good readers/poor spellers, 8% were poor in both and the rest of the children were good in both. They found that the phoneme deletion skills of all three deficit groups were not impaired; indicating that at older grades PA loses its predictive validity due to the transparency of orthography, in agreement with other studies investigating consistent orthographies (Landerl & Wimmer, 2000). However, this was not the case for RAN. In their group of poor readers/poor spellers they found that RAN was associated with reading speed and PA with spelling skill which concurs with other studies (Moll et al., 2009). The researchers conclude that for this particular group of poor readers and spellers the reading deficit might be associated with slow visual-verbal access, whereas the spelling deficit might be associated with phonological ability. Findings deriving from the poor readers/ good spellers group were also interesting as this particular group's phonological ability was intact and they had a marked impairment only in RAN. The researchers attribute the deficit to impaired access from visual input to phonological output. This visual-verbal deficit will affect, according to the researchers, both real word and nonword reading as access to small graphemic units will be also detrimental. Finally, the group of good readers/ poor spellers did not have a RAN deficit, indicating that their visual-verbal mapping was intact. The researchers speculate that maybe an early deficit in phonological ability might have been the cause of spelling impairment, similarly to Wimmer and Mayringer's (2002) study.

Cardoso-Martins and Pennington (2004) found in a longitudinal study that RAN was associated with later spelling performance of English speaking children (age 7 years), after controlling for IQ. A similar result was observed by Lervag and Hulme (2010) investigating a group of 228 Norwegian children for three years from age six. They found that nonalphanumeric RAN was a longitudinal predictor of real and pseudoword spelling. Alternatively, Landerl and Wimmer (2008) found that PA and not RAN was a longitudinal predictor of German spelling. In a longitudinal study conducted with Dutch monolingual participants Verhagen et al. (2010) found that both RAN and PA predicted spelling in early Grade 1, later Grade 1 and Grade 2. However, PA was more strongly associated with spelling at the beginning of Grade 1. In all the analyses PA and RAN correlated modestly with each other.

In a study conducted by Georgiou et al. (2012b) they compared three different orthographies (English, Greek & Finnish) in terms of letter awareness, PA and RAN in pre-schoolers. Using path analyses they found that letter awareness, which was the strongest longitudinal predictor, had the same effect for Greek and Finnish reading. The situation was different for spelling, however. The strongest predictors of spelling were letter knowledge and RAN, and the effect of these did not differ for Greek and English, which are less transparent for spelling than Finnish. In Finnish letter awareness was the strongest longitudinal predictor of both reading and spelling as for Finnish both orthography to phonology and the opposite direction is highly consistent. Torppa et al. (2013) also conducted a large scale study with Finnish children looking into longitudinal predictors of reading and spelling in a large sample of 1,006 children with no reading skills at the beginning of kindergarten. Children were divided into four groups, one with no deficit, one with a phonological deficit, one with a RAN deficit and one a double deficit. In agreement with other studies looking into the double deficit hypothesis they found that children with double deficit experienced the most severe difficulties in reading and spelling (Papadopoulos et al., 2009). The researchers also reported that PA was more strongly associated with spelling skill of all four groups of children than RAN and that the finding is consistent with relevant studies investigating transparent orthographies (e.g., Landerl & Wimmer, 2008).

In a large cross-linguistic study conducted by Caravolas et al. (2012) comparing four different orthographies (English, Spanish, Czech and Slovak), the researchers found that letter knowledge, PA and RAN were all strong longitudinal predictors of reading and spelling. The researchers conclude that a child, in order to read and spell accurately in both transparent and opaque orthographies, needs good awareness of correspondences between phoneme and graphemes, good phonological ability and finally, fast and accurate ability in word retrieval.

Interim summary

Certain research evidence indicates that RAN could relate to orthographic processing, as a deficit in RAN could prevent fast access to verbal labels of visually presented information and this can affect automaticity and integration of visual information about letter sequencing in words (Bowers & Newby, 2002; Wimmer et al., 2000; Manis, Doi,

& Bhadha, 2000). By contrast, other researchers found evidence relating RAN with phonological processing (Vellutino et al., 2004). Other studies have also indicated that RAN is independent from PA (Kirby, Parrila, & Pfeiffer, 2003; Manis et al., 2000), or from phonological short-term memory and phonological ability (Powell et al., 2007). Research evidence also seems to favour the notion that PA is more strongly associated with spelling skill than rapid naming. Additionally, there are only a few studies looking into the relation between RAN and spelling, and the results are contradictory.

Visual short-term memory

Research findings relating visual short-term memory to spelling skill are less conclusive in comparison to those relating PA and phonological STM to spelling. Giles and Terrell (1997) in their study of poor spellers with mean age 14;03 concluded that visual sequential memory (employing nameable and non-nameable pictures) did not have a significant role in spelling for these children. The study involved two experiments with students divided into “Phoenician” and “Chinese” groups based on qualitative analyses of spelling errors. They found a difference between visual memory scores for the two groups for nameable pictures in the first experiment, but they could not replicate the results with a new group of participants matched in intelligence in a second experiment.

Alternatively, Stuart, Masterson, and Dixon (2000) conducted two training studies with five-year-old novice readers. Children were screened and formed two groups of ten pupils according to ability to segment the initial phoneme of heard words and match with printed letters of the alphabet (they termed this graphophonic skill). The aim of the first training study was focused on finding whether graphophonic skill might enhance sight vocabulary acquisition or whether this might be attributed to rote learning of arbitrary associations, as proposed in Frith’s logographic stage (1985). The results were not supportive of a logographic stage, at least for the children with good graphophonic skills. For children with poor graphophonic skill the ability to learn new words correlated significantly with visual memory scores, as measured in Goulandris and Snowling’s (1991) sequential visual memory task (where unfamiliar symbols were presented one after the other and the child was subsequently asked to point to the test items from array, see Study 4 for a full description of the task). The same relationship was not found for the children with good graphophonic skills, albeit visual memory scores did not differ overall across the two groups. The interpretation was that the children with poorly developed phonological and letter-sound knowledge were forced to rely on visual memory to learn new printed word forms, while the children with good graphophonic skills could use phonological skills to underpin developing orthographic representations.

Single case studies of participants with surface dyslexia and surface dysgraphia have looked at the effect of visual memory on reading and spelling. Goulandris and Snowling (1991) assessed JAS, a developmental dyslexic who appeared to have intact performance in tasks tapping PA but poor performance in reading irregular low frequency words, as well as a spelling impairment. JAS was shown to have impaired visual memory, as assessed by report of arrays of Greek letters. The authors suggested that the visual memory deficit may have led to the difficulty in forming detailed orthographic representations. Visual memory was also investigated in a case study with a developmental surface dysgraphic adult, AW. Romani, Ward, and Olson (1999) reported that AW showed poor performance when unfamiliar symbols were presented sequentially but not when they were presented simultaneously. They argued that his spelling difficulty could be the result of a problem with the encoding of serial order in visual memory.

On the other hand, Caravolas et al. (2001), in their longitudinal study with four-to-eight-year-old children found that PA was a strong predictor of spelling performance while visual memory was not associated with spelling. In this study, visual memory was assessed using a task developed by McDougall et al. (1994). The task required recall of arrays of abstract letter-like shapes. Each shape was shown for 2 seconds and then it was removed and replaced by a new shape. At the end of stimulus presentation the child had to point, in the correct order, to the shapes she/he saw in the test phase using a display sheet of 12 shapes used in the task. However, visual memory scores in the study seem to be low at all three times of assessment (Time 1=1.68, *SD*=0.45; Time 2=1.64, *SD*=0.45; Time 3=1.86, *SD*=0.48), and this may be why the relationship to spelling performance was not detected.

Holmes, Malone, and Redenbach (2008) also reported a failure to find evidence of inferior visual memory ability in unexpectedly poor spellers. The visual memory task used involved simultaneous or sequential presentation of symbol sequences and participants had to reproduce the arrays in the correct order. Participants were 86 students in the first experiment and in the second experiment 87 participants. Although in Experiment 1 they found that the unexpectedly poor spellers had impairment in visual sequential memory they were not able to replicate this finding in their second experiment. In Experiment 2, apart from the reproduction task two control tasks were also used, symbol recognition and symbol discrimination. Participants in Experiment 2 were a different group of students. The researchers attribute the discrepancy between their results and Romani et al.'s (1999, see above) case to the severity of spelling difficulty. That is, the spelling difficulty of their unexpectedly poor spellers may not have been as severe as that of AW.

Masterson et al. (2008) investigated the role of PA and visual memory in spelling in a cross-linguistic study with 50 six-year-old English and Greek participants (see also page 73 and 80 of the current thesis). The visual memory task in this study was presented in two versions – one involving familiar pictures and the other abstract designs (see Study 1 for a description of the task). They found that PA scores were a significant predictor of spelling performance for the Greek children, while for the English children both PA and scores in the visual memory tasks predicted spelling performance.

Mumtaz and Humphreys (2001, 2002, see also section 2.5.1 of the current thesis) carried out a study with bilingual Urdu- and English-speaking seven-to-eight year-old children. They compared performance in reading regular words, irregular words and nonwords as well as scores in PA tasks and in the Doors task of visual memory (Baddeley et al., 1994) in children with stronger and weaker Urdu vocabulary skills. They found that the children with stronger Urdu vocabulary were better in PA tasks and at reading English regular words and nonwords compared to the children with weak Urdu awareness. On the other hand, they performed poorly in irregular word reading and in the visual memory task compared to children with weak Urdu awareness. In contrast, the children with weak Urdu vocabulary awareness were better at reading English irregular words and in visual memory, but they performed significantly lower in the PA tasks and at nonword reading. The findings suggest that greater knowledge of transparent Urdu led to reliance on phonological skills for reading, while weaker knowledge of Urdu led to reliance on whole-word/visual skills.

Interim summary

The studies that have investigated the relationship of visual memory and spelling have produced contradictory findings. Those studies that have looked at the relationship in young typically developing children mainly found that an association between visual memory and spelling exists. The studies that failed to find a significant association between spelling in English and visual memory was the Caravolas et al. (2001) and the Giles and Terrell (1997) studies and this might be attributed to the visual memory task used, which seemed to result in low levels of performance at least for the Caravolas et al. study. Therefore the difference between the findings from the Caravolas et al. study and the other studies might be due to the task's characteristics, as it seemed to be too difficult. Given the recent accumulation of evidence that visual memory may play a role in the acquisition of lexical representations, especially for English speaking children, it was incorporated into investigation of the processes involved in spelling in the present monolingual and bilingual Greek and English speaking groups. Therefore, it was considered important to investigate, following the research findings of Masterson et al. (2008) and Mumtaz and Humphreys (2001, 2002), the association of visual memory with spelling in monolingual and bilingual Greek- and English-speaking children with typical and atypical spelling performance, to see whether differences would be observed between the groups.

Morphological awareness (MA)

There is now research evidence suggesting that morphological awareness (MA) is also a significant factor in accurate spelling (for example, Bourassa, Treiman, & Kessler, 2006; Nunes, Bryant, & Bindman, 2006a; Nunes & Bryant, 2006; Kirby et al., 2008, Garcia, Abbott, & Berninger, 2010, for English; Nagy et al., 2002, for Chinese; Defior et al., 2008, for Spanish; Nunes et al., 2006b for Greek). Carlisle (1995, p. 194) described MA as children's "conscious awareness of the morphemic structure of words and their ability to reflect on and manipulate that structure". Carlisle's (1988) cross-sectional study with 65 fourth, sixth and eighth Graders in the USA investigated the acquisition of derivational morphology in spelling. She concluded that a precondition for correct spelling of derived words is the awareness of the base word. She also noticed a developmental trend in learning the correct derivational morpheme (33% to 87% between 4th and 8th Grade) and that the more complex phonologically and orthographically is the relationship between base and derived word (e.g. heal and health) the more error prone is the spelling of the derived form.

Nunes, Bryant, and Bindman (1997a, 1997b, 1997c) conducted a cross-sectional spelling study with second, third and fourth grade children assessed at three time points. To assess morphological awareness they used a word and sentence analogy test (for a description of the word analogy task see pages 96-97 of the current thesis). An example of the sentence analogy task is: /Tom **helps** Mary/; /Tom **helped** Mary/; /Tom **sees** Mary/; /-------------/, correct response: /Tom **saw** Mary/. Results revealed that children began spelling phonologically and that they needed at least 2-3 years of instruction in order to master morphological rules. For example, children spelled *kissed* -> KIST initially and later they adopted the correct -ED spelling for the ending. At the beginning children would over-generalise spelling rules and later on, they adopted the correct spelling. Garcia et al. (2010) also conducted a cross-sectional study in the USA. They found that MA was significantly associated with correct spelling in older children (mean age 8.7 (*SD*: .31), with tasks also tapping, apart from MA, syntactic knowledge.

An intervention study conducted in the UK by Hurry et al. (2005) further supported the role of MA in spelling performance. 686 Children attending Years 3 to 6 took part in the intervention which lasted seven weeks. The intervention classrooms received explicit teaching of morphological rules whereas the control classrooms received only instruction in comprehension. At the first follow-up assessment all groups showed improvement in spelling of real and nonwords, but the MA classrooms demonstrated better performance (real word spelling test effect size=.50 and nonword spelling effect size=.48). One year later, spelling assessment of children, in one of the schools where intervention took place, showed significantly better results for the MA group in comparison to the control group which had had normal school lessons (based on the National Literacy Strategy).

Carlisle (2010), in a review of 16 studies investigating the relationship between MA and phonology, orthography and semantics, concluded that MA is significantly associated with all three areas of literacy development and that it helps students crystallize their awareness of spelling, morphemic structure and meaning. Based on the findings from seven studies which focused primarily on the association between MA and orthographic development (three of the studies were carried out with English participants and four with Chinese) Carlisle concluded that explicit teaching of morphology significantly improves spelling.

Looking into studies with children with atypical spelling performance, Bourasssa et al. (2006), Bourassa and Treiman (2008) and Egan and Tainturier (2011) found that dysgraphic participants did not differ significantly from younger age controls in morphological ability. Bourassa et al. (2006) used a spelling-level match design with 19 dyslexic children (mean age 11;05) and 25 TD spellers (mean age 7;08). They investigated the use of morphological rules in spelling in two experiments. In the first children were asked to spell morphologically complex words (e.g., *shared*) and simple (e.g., *beard*) words and in the second they used in the spelling task morphologically simple and complex words but also control stem words (e.g., *eat*). All items in the second experiment contained *t*- or *d*-flap consonants. They concluded that although dysgraphi children used morphology to spell a word (for example, they might correctly spell *waiting*), this was not consistent and children did not make full use of morphological information (for example, spelling *tune* correctly did not help them spell *tuned*, they frequently omitted the <n> in the latter).

Egan and Tainturier (2011) reported that dysgraphic children's spelling of past-tense was predicted by lexical orthographic memory (as assessed by irregular word reading and spelling) and not spoken MA, as assessed by tasks involving inflecting nonwords, morphological judgment and sentence analogy. The latter two tasks predicted TD children's spellings. They attribute this difference to dysgraphic children's inability to effectively use spelling strategies (such as morphological rules) and their unsuccessful attempts to memorise orthographic patterns. Goodwin and Ahn (2010) conducted a metanalysis of seventeen intervention studies (15 with English-speaking children with literacy difficulties) focusing on MA. Sample size in studies included ranged from 15 to 261 children, children attended a wide range of Grades and intervention lasted from 3 to 24 weeks. The researchers found that MA intervention had a significant positive effect on spelling performance in spelling disabled children.

Turning now to the Greek writing system, Aidinis (1998) in a cross-sectional study conducted with 7 to 10 year-old children, found that a developmental sequence in spelling was observed similar to that found in English children. Initially children use a phonological strategy (choosing the most common vowel grapheme among the alternative graphemes), older children adopted the alternative vowel/s instead of the most common and over-generalised, and only at Grade 5 children consistently spelled using the correct morphological rule. In a multiple regression analysis Aidinis found that morphological awareness predicted correct spelling of morphemic ending and stem of the word even after controlling for age and verbal ability. In 2002 Chliounaki and Bryant in a longitudinal study with 105 first graders concluded that children proceed via the aforementioned developmental pattern in order to reach the conventional spelling. However, in spelling the stem, they observed fewer overgeneralizations of the alternative spelling grapheme. The researchers attribute this to the child's awareness of the arbitrariness of the word's stem and the need to learn the conventional spelling via rote.

In another longitudinal study conducted by Chliounaki and Bryant (2007) with 90 children aged 6 at the outset, children were asked to spell real words and pseudowords. The researchers found that at Time 3 children were significantly more accurate in pseudoword spelling (70.6%, while at outset 49%) and that children were always better at spelling real words than pseudowords, indicating that word-specific knowledge constitutes a significant factor in accuracy. They also claim that there is a developmental trend as children first establish word specific knowledge for spelling and later, via this knowledge, they gain MA. The importance of MA for the Greek language was also demonstrated by Diamanti et al. (2013) who reported a group study with Greek-speaking dyslexic children aged 12 years and same age and spelling ability controls. They found that the children with dyslexia had difficulties in applying morphological rules when spelling word suffixes. The association between MA and spelling has not yet been investigated in bilingual children and the differences in English and Greek morphological structure might reveal different patterns, if MA plays a causal role in spelling development, across the groups.

Vocabulary

Vocabulary is the amount of words a person knows (Anderson & Nagy, 1992). It entails two major components: the ability to effectively use vocabulary in oral communication or in print (expressive vocabulary), and the ability to understand a word (otherwise known as receptive vocabulary) (Kamil & Hiebert, 2005). Vocabulary has been found to be strongly associated to reading skill (NICHD, 2000; Verhoeven, Leeuwe, & Vermeer, 2011) and reading comprehension (Beck et al., 2002; Nagy, 2005). By contrast, research looking into the association of vocabulary and spelling is sparse, although a few studies have investigated the association between semantic awareness and orthographic learning.

According to Verhoven and Perfetti (2011, p.1) "vocabulary growth is the increased representation of word meanings (semantic awareness) and their corresponding word forms (orthographic awareness)". Cunningham and Stanovich (1991) in a cross-sectional study with 4th, 5th and 6th Grade students reported a high correlation between vocabulary and spelling performance (r=.32, p<.05), although in this study main interest was in the association between print exposure and literacy skills. Share (1995, 1999, see also page 61 of the current thesis) investigated semantic and orthographic learning. In the Share (1999) study he presented Hebrew-speaking children aged 8 with novel nonwords embedded in sentences or short texts. The children had to practice reading the sentences and texts and later they were tested in spelling to dictation/or recall (where they were required to choose the target when it was presented together with a foil). Share concluded that learning to spell the new words was a result of practicing reading (applying GPCs) and not just visual exposure to the word. He based the latter on a second experiment where children had to do concurrent articulation and received brief exposure to target nonwords via a lexical decision task. The outcome was that children spelled poorly the target nonwords (39% accuracy) in comparison to the first experiment (54% accuracy).

Following Share's study, Ouellette and Fraser (2009) in a study with 35 fourth graders (mean age 9;06), trained children with 10 novel nonwords. Half of the nonwords were coupled with semantic information, and half were not, and the training involved reading of the nonwords. In the follow-up assessment the researchers found that training of nonwords, coupled with semantic information, generalized to a visual word recognition task. However the same training did not generalize to spelling. The visual word recognition task needed children successfully to select the target item among three foils (e.g., *wote*: target nonword, *woat*: homophonic mate, *wode*: visually similar foil, and *woet*: transposed letter foil). The researchers concluded, in agreement with findings from a study conducted in Hebrew by Shahar-Yames and Share (2008), that no significant effect was observed for spelling the nonwords as the training included only reading, which does not seem to generalise to spelling. However, Shahar-Yames and Share observed that training in spelling improved spelling and reading accuracy for taught items. The researchers claimed that this is the case as spelling demands more skills, apart from visual word recognition, such as awareness of phoneme-grapheme correspondences and motor-kinesthetic skills. Ouellette and Fraser also conducted multiple regression analyses with spelling performance as the dependent variable and phonological awareness, nonword and irregular word reading and receptive vocabulary as predictor variables. They found that only nonword reading and receptive vocabulary accounted for significant variance in spelling performance, even if vocabulary was entered in the regression model after irregular word reading, which is found to share unique variance with vocabulary (Ouellette, 2006; Ricketts, Nation, & Bishop, 2007).

In 2010 Ouellette conducted a training study following the same paradigm (Share, 1999) with 36 children with mean age 7;10. As in Ouellette and Fraser's (2009) study, the children were taught 10 novel nonwords, half of which were coupled with semantic information. Eighteen students practiced spelling the words and the other 18 practiced reading the words. Testing took place one and seven days after the training. Children were assessed in a spelling-to-dictation task. There was a significant main effect of practice type, with spelling being superior to reading practice, and a significant effect of teaching strategy where spellings coupled with semantics were better retained. Accordingly, Perfetti (1997, 2010) suggests that spelling requires highly specified representations and that inclusion of semantics in the training augmented the effectiveness for both spelling and orthographic learning. The latter finding indicates that semantic information contributes to better integrated lexical representations. Perfetti and Hart (2002) in the *lexical quality hypothesis* argued that in order for a lexical representation to be of high quality, it must possess a clear and specific orthographic representation, as well as phonological information from spoken language and from the connection between orthographic-to-phonological correspondences. Lexical quality is low when additional information and specificity is weak. Retrieval of the word in this case will be effortful with connections among orthography, phonology and semantics loose. Where links are strong between phonology, orthography and semantic information, retrieval of a word's spelling will be accurate and fast. The result of Ouellette's (2010) study also suggests that training in reading does not suffice for accurate spelling; however, the opposite (training in spelling) usually results in improvement in reading.

In a cross-linguistic study conducted by Caravolas et al. (2005b, the study is also presented in section 2.5.1.2.) the researchers assessed Czech and English school-children matched in age and non-verbal ability in tasks tapping vocabulary, spelling, reading, reading comprehension and PA. The researchers conducted path analyses using in each model spelling in Czech and in English as the criterion variables and non-verbal ability, vocabulary (as assessed by the WISC-III, Wechsler, 1992, in both languages), digit span, coding, PA and reading speed as the predictor variables. They found that vocabulary in both languages strongly predicted spelling as well as PA and reading speed. They attribute the significant association between vocabulary and spelling, even for the transparent Czech orthography, to the fact that vocabulary is associated with lexical orthographic knowledge which is important for accurate spelling. This finding comes to contradiction to Shares' (2008) argument that lexical variables such as vocabulary are less associated with transparent orthographies, since transparency leads to reliance on sublexical processes. A point that should be made is that Share posits this argument based on results deriving from reading and not spelling.

The relation between vocabulary and spelling has also been studied in participants with atypical spelling performance. Holmes and Ng (1993) in an experimental study with good and poor adult spellers found that the poor spellers had lower vocabulary skills than the good spellers. However in an earlier study, Fischer, Shankweiler, and Liberman (1985) with university students did not find any significant differences between good and poor spellers' vocabulary performance.

Finally, in a study conducted by San Francisco et al. (2006) with bilingual English-and Spanish-speaking participants in Boston the researchers found that children with strong Spanish vocabulary (as assessed by an expressive vocabulary test) were prone to make more Spanish-influenced spelling errors in English. Additionally the researchers found that English vocabulary awareness predicted nonword spelling in English for both bilingual and monolingual Spanish- and English-speaking children.

The role of vocabulary and its association with spelling skill has not been investigated with English- and Greek-speaking bilingual children and this is going to be the unique contribution of the current thesis. Additionally, in case study reports (see Chapter 7) the role of vocabulary in multilingual and monolingual children with atypical spelling performance will be investigated.

Print exposure

Print exposure has also been considered to be an important variable affecting literacy development. Stanovich (1986) wrote about the *Matthew effect* which describes the reciprocal relationship between reading and other cognitive skills. He argued that children with a good early start in reading will engage more in literacy activities such as reading and writing in contrast to children with a poor start. The latter will find themselves dealing with difficult material, will exhibit more frustration and less reward, and this will eventually lead to less engagement. This resultant lack of exposure will hinder automaticity and scaffolding of high quality lexical representations. Stanovich and colleagues in a series of experiments (1990, 1991, 1992, 1997) investigated the relation between print exposure and literacy ability testing the validity of *Matthew effects* in educational achievement.

Cunningham and Stanovich (1993) in a study with 26 6-7 year old first Graders found that print exposure accounted for significant variance in an experimental spelling task and in the standardized Stanford Achievement spelling test (21.2% and 43% respectively) even when they controlled for phonological ability. Print exposure was assessed via a title and an author recognition task. The researchers conclude that orthographic processing is linked to print exposure independently from phonological processing.

Cunningham and Stanovich (1997) conducted a longitudinal study with 56 first Graders who were followed to 11^{th} Grade. At the final assessment they were able to assess 27 students (mean age 16;09) in reading comprehension, written vocabulary, receptive vocabulary, non-verbal ability, measures of print exposure and general knowledge measures. They demonstrated that children with a good start in reading skills were more engaged in reading activity later and this was predicted even when 11^{th} grade reading comprehension was partialled out. Another significant finding that emerged was that 11^{th} Grade print exposure accounted for significant variance in both written and receptive vocabulary at the same age (37% and 13.5%, respectively). Finally, in a cross-linguistic study conducted by Kalia and Reese (2009) with Kannada- English speaking children parental English book reading was found to be a strong predictor of literacy development in L2. Consequently, print exposure seems also to be a significant factor affecting children's spelling performance.

3.3. Stimulus-related variables associated with printed word production

A range of stimulus characteristics such as printed word frequency, word-length and least phonographeme frequency have been found to affect spelling (e.g., Spencer, 1999, 2007, for English, Loizidou et al., 2009 and Masterson et al., 2008, for Greek). These stimulus-related variables will be examined next.

Frequency, word length and least transparent phoneme-grapheme probability

Spencer (2007, see also section 2.4.1 for a review) carried out a study of spelling in 207 UK pupils from Years 2 to 6. Using correlation and regression statistical techniques he found that the strongest predictors of the children's spelling were printed word frequency, phonographeme frequency and transparency, number of complex graphemes in a word and word length. The results of Spencer's (2007) study therefore indicated that spelling (in English) is influenced by both lexical and sublexical processes in young children as both lexically related variables, such as printed word frequency, and sublexical ones, such as word length and phonographeme probability affected the children's spelling performance. Least transparent phonographeme (LTPG) values were also used for the current study because LTPG was found to be the strongest predictor of spelling performance in Spencer's (2007). LTPG values were obtained for the stimuli, rather than overall or average phonographeme values for each word, or an alternative. According to research findings (Spencer, 1999, 2007) older English children's spelling performance is more strongly associated with frequency. Spencer also noted that the effect of frequency helps to minimize misspellings due to the inconsistency of the graphemes (e.g. the sound /e/ spelled as *den* (probability of occurrence 90%) or *said* (probability of occurrence 0.6%)).

Similarly, printed word frequency and letter length were found to be strong predictors of spelling in Masterson et al.'s (2008) study with 35 children attending an inner-London school (see also pages 72 and 73 and 80 of the current thesis). Similarly, with the above-mentioned studies, Martinet, Valdois, and Fayol (2004) found that French-speaking children are sensitive to printed frequency as soon as formal instruction begins. Children were tested in spelling real words and nonwords. Apart from the effect of frequency for words, for nonword spelling a strong analogy effect was observed. The findings indicate that lexically related variables are important from the beginning of spelling acquisition for opaque writing systems. The significance of frequency for English-speaking children's spelling was also asserted by Treiman (1993).

Turning now to studies with Greek students, word length in letters was found to affect spelling performance of Greek Grade 1 children by Masterson et al. (2008) (see also pages of the current thesis 72, 73 and 80). Printed word frequency was also examined in relation to spelling but it was not found to show a significant association. This indicates a reliance on sublexical processing for spelling, as word length is considered to be a marker of sublexical processing for both reading and spelling (e.g. Share, 2008; Spencer, 2010). Masterson et al. (2008) also reported a strong effect of least transparent phonographeme probability in the children's spelling. Younger Greek participants (aged six and seven years) tested by Loizidou-Ieridou et al. (2009) (see also section 2.4.1 of the current thesis) manifested a strong effect of phoneme-grapheme regularity on spelling accuracy, indicating stronger reliance on sublexical processes. Older children's (9-to-10-years-old) spelling performance was also affected by frequency. Harris and Giannouli (1999) found, in Grade 3 children, a strong frequency effect for spelling Greek words. High frequency regular words were easier spelled than the low frequency ones. It seems that for younger Greek children, sublexical processes play a more significant role in children's spelling. Alternatively, as children grow older and gain more experience with print, lexical processes have a significant role.

A unique contribution of the present study was to investigate the effect of the variables of frequency and least transparent phonographeme probability on the spelling of bilingual Greek- and English-speaking children, who were simultaneously acquiring a transparent and an opaque writing system.

3.4. Discussion

3.4.1. Current research: Study 1, 2 and 3

The group studies reported in studies 1 to 3 had two aims. The first was to investigate intra-linguistic and cross-linguistic factors that affect spelling in Greek and English monolingual and bilingual children. Intra-linguistic factors are child-based and stimulus-based variables. For the child-based variables, pupils' phonological ability, rapid automatized naming, verbal and visual short-term memory, letter report, morphological awareness, receptive vocabulary and print exposure were assessed. For the stimulus-related variables, printed word frequency and least transparent phonographeme value were examined. These variables were investigated in relation to pupils' performance on a single word spelling task developed for cross-linguistic research by Masterson et al. (2008). The investigations aimed to elucidate the factors that affect the spelling of a monolingual and a bilingual sample with typical spelling performance and whether the processes involved in spelling development in a first and a second language are different or the same. Thus, Study 1 investigated a range of variables aiming to find among them those that were most strongly associated with spelling performance.

Studies 1 to 3 also investigated language transfer effects in the bilingual children's spelling performance. There is now good evidence that cognitive and linguistic abilities which are involved in literacy acquisition transfer from one language to another (e.g., Koda, 2008). The focus of the present research was on how knowledge of (transparent) Greek affects spelling performance in opaque English in Greek-English bilingual children. In previous research cross-linguistic and intra-linguistic factors in reading were investigated in English-Urdu bilingual children by Mumtaz and Humphreys (2002, see section 2.5.1. & 3.2.). It was considered informative to see whether transfer effects in spelling could be observed for Greek- and English-speaking bilingual children. Niolaki (2009) found cross-linguistic transfer of skills not only in the type of errors made in both languages but also by the strong interference effect observed in the weaker language (children with weak knowledge of Greek made many errors involving use of English, particularly they used English letters and PGCs in their spelling of Greek). This corroborates findings of Howard et al. (2006) and Figueredo (2006) (see for a review section 2.5.1. & 2.5.1.1.).

Further investigation of the factors identified by Niolaki (2009) was considered to be informative as phonological awareness was found to be a significant predictor of spelling in English for bilingual children with stronger Greek literacy skills, and visual memory for the bilingual children with weaker Greek literacy skills. An extension of Niolaki's findings in Study 2, incorporating a longitudinal design, was considered important in order to establish whether there may be developmental change in the pattern observed. Thus, Study 2a and 2b investigated longitudinally the association of single word spelling performance with PA and visual memory in a group of bilingual Greek- and English-speaking children with weaker and stronger literacy skills in Greek. Finally, Study 3, with a new sample of monolingual and bilingual children looked into the role of simultaneous multi-character processing, as measured in the letter report task, as a possible lexically-related variable. This variable has been extensively researched in association with reading (see for example studies carried out by Valdois and colleagues, presented in Chapter 6) but not with spelling of monoliterate or biliterate children. An accumulation of evidence (reviewed in Chapter 6) over the course of conducting my PhD studies indicated that this variable might be a powerful lexically-related variable that could be employed in studies investigating predictors of spelling in monolingual and bilingual children.

Research questions for Study 1, 2 and 3:

- Which child- and stimulus-related variables are significantly associated with performance in spelling-to-dictation in Greek-English monoliterate and biliterate children aged 7 to 10 years?
- Does the transparency of Greek lead to reliance on sublexical processes in spelling?
- Conversely, does the opaqueness of English lead to lexical reliance in spelling?
- Is there a developmental trend in the patterns observed?

Chapter 4

4. Child- and stimulus-related variables associated with English and Greek spelling performance in monolingual and bilingual Greek- and English-speaking children

4.1. Study 1: A cross-sectional investigation

Introduction

The purpose of this study was to investigate the child- and stimulus-related variables associated with spelling performance for monolingual and bilingual Greek- and English-speaking children. Younger children (mean age 7 years) and older children (mean age 9 years) were assessed in order to investigate possible developmental trends in performance. Factors that have been found to play a significant role in bilinguals' and monolinguals' spelling were examined. Specifically, child-related variables of non-verbal ability, PA, phonological memory, visual memory, rapid automatized naming (RAN), vocabulary, morphological awareness and print exposure were investigated. Additionally, stimulus-related variables of frequency and least transparent phonographeme probability were examined.

Most research into literacy acquisition up to now has been conducted with English-speaking and monolingual participants. Cross-language studies have addressed the significance of orthography and characteristics of each language in acquiring literacy, as discussed in the literature review. Specifically, research carried out in different orthographies has stressed that there is a different pace of literacy acquisition (for example see section 2.5.1.2, Wimmer, 1993; Landerl & Wimmer, 2000) and that variables such as PA or RAN can play a different role depending on the characteristics of each orthography (see section 3.2, Moll et al., 2009; Nikolopoulos et al., 2006; Caravolas et al. 2012; Ziegler & Goswami, 2005). Since Greek and English writing systems differ in opaqueness, another aim was to explore the role of visual memory. In Masterson et al. (2008) and in Niolaki (2009) it was found that visual memory was associated with spelling skill of English monolingual children and bilingual children depending on their Greek literacy awareness skills, but not with the spelling performance of Greek monolingual children and bilingual children with strong Greek literacy ability, for whom PA was the only significant predictor. The findings indicate that an optimal (phonological) strategy used in a transparent orthography is transferred to spelling in English, an opaque writing system. It was considered important in the present study to investigate whether similar associations would emerge in the spelling skill of monolingual and bilingual Greek- and English-speaking children differing in age. The role of morphological awareness in spelling has also been investigated, both in

Greek (Aidinis, 1989) and in English (Nunes et al., 2006a). Vocabulary and print exposure have also been reported to be significantly related with spelling for English children but not for Greek children or bilingual Greek- and English-speaking children. Thus, Study 1 addressed this issue for first time. Ouellette and Fraser (2009) found a relation between spelling and vocabulary knowledge as outlined in section 3.2. Although morphological awareness, vocabulary and print exposure have been investigated in relation to the performance of monolingual children, less research is reported on bilingual children (see also section 3.2.).

These variables were examined in the present study, initially by carrying out correlational analyses and then by conducting regression analyses, for groups of younger and older monolingual and bilingual children. In the regression analyses the aim was to investigate, first, predictors of English and Greek spelling in monolingual children. An additional aim was to ascertain whether there was a developmental change in the association of the variables with spelling, as has been found in studies of reading. For example, developmental differences in simultaneous multi-character processing ability and PA (Bosse & Valdois, 2009, see also Chapter 6), in rapid naming and PA (Di Filippo et al., 2005), in orthographic and phonological processing (Hagiliassis et al., 2006) have been found for reading.

A final aim of Study 1 was to examine whether there was evidence of transfer of processes used in spelling from one language to another in the pattern of association of variables in the bilingual children. It proved possible to match the spelling ability in English of the English-speaking monolingual children with that of the bilingual children. The same matching was not possible for spelling in Greek of the monolingual Greek-speaking and bilingual children. This was due to the fact that testing bilinguals was only possible in the UK and most of the bilingual participants were learning Greek as a second language. Since the English-speaking children and bilinguals were spelling at a comparable level of ability (in English) then any differences observed in the predictors of spelling of the two groups could not be due to differences in spelling ability level. These differences would be likely due to the influence of knowledge of transparent Greek in the bilinguals. Evidence for transfer effects would therefore be if the pattern of predictors of spelling in English for the bilinguals shared aspects of those observed for both groups of monolinguals, rather than simply being the same as that found for the English monolinguals. Due to the matching criteria adopted only predictors of English spelling in the bilingual children (and not predictors of Greek spelling) were examined. This was because the bilingual children's Greek spelling ability was significantly low in comparison to that of the monolingual Greek-speaking children, therefore comparisons were not feasible (see page 89).

Method

The present study aimed to investigate how a range of child- and stimulus-related variables were associated with spelling performance of younger and older monolingual and bilingual Greek- and English-speaking children in a cross-sectional design. This is a quantitative study with an explanatory aim, as it focuses on identifying the factors that predict spelling in two languages. The study is cross-sectional as younger and older children were compared for both the monolingual and bilingual groups. Quantitative and qualitative data analyses were conducted. Quantitative analysis involved correlation and multiple regression analyses, and qualitative analysis involved examination of the types of spelling errors made by the children.

The children recruited to this study were aged 7 and 9 years old on average. Children of these ages are still acquiring spelling skills, and so provide optimal opportunities for examining spelling performance for evidence of cross-orthographic influence (Seymour et al., 2003).

Participants

Younger group

Monolingual English-speaking children

There were 31 monolingual English-speaking participants from Years 2 and 3 (mean age 7;07, *SD*=0;05, range 6;09-8;07), 13 of whom were girls. Children were recruited from four different schools in North London. The chronological ages of the children in the four schools were compared using one-way ANOVA and there was no significant group effect (F<1). In addition, one–way ANOVAs revealed no significant group effect across schools for non-verbal reasoning scores, or reading and spelling accuracy in the assessments described in the Materials section (all Fs<1). Literacy instruction in all of the schools, as reported by the teachers, involved a combined whole word and phonics-based approach. The researcher completed a language experience questionnaire with each child (see Appendix A.1.). The children reported that they spoke only English at home. A summary of scores in background assessments of nonverbal ability and reading and spelling for children in the monolingual English group, the monolingual Greek group and the bilingual group is given in Table 3.

Monolingual Greek-speaking children

The young monolingual Greek group was matched in age and non-verbal reasoning to the monolingual English group. There were 39 children (mean age 7;08, *SD*=0;04, range 7;01-8;02), 15 of whom were girls. Children were drawn from a private summer school and a state primary school in Crete. They attended Grades 1 to 2, equivalent to English school Years 2 to 3. Literacy instruction in all of the schools, as reported by the teachers, involved a phonics-based approach. The language experience questionnaire (see Appendix A.1.) results revealed that the children reported they spoke only Greek at home.

Bilingual children

The young bilingual group was matched to the monolingual children in age and non-verbal ability. The group comprised 35 children from Years 2 and 3 (mean age 7;09, *SD*=0;04, range 7;00-8;05), of whom 20 were girls. Eleven of the children attended a morning Greek independent school and the remainder attended four different Greek afternoon schools in London, UK. There were no significant differences in age or background assessment scores of the children in the different schools. The morning school followed the Greek national curriculum and children received instruction in Greek language arts for eight hours per week and English literacy for ten hours per week. Most of the children spoke Greek at home. The afternoon school was for five hours per week, and approximately four hours were devoted to Greek literacy instruction. Children attending the afternoon schools attended mainstream English schools during the day. Pupils in both types of school were instructed in Greek literacy using an analytic and synthetic phonics approach, and in English literacy by a combination of whole word and phonics methods. The sequence for instruction in Greek literacy is as follows. Pupils are taught the basic letters of the alphabet and how to read and write simple words using these letters. Then the children are taught digraphs, trigraphs, diphthongs, consonant and vowel clusters, and some basic grammatical rules which will guide their spelling. Teachers are allowed flexibility in choosing a primer from a wide range of materials written for pupils learning Greek as a second language. The results of the language experience questionnaire (see Appendix A.1.) revealed that 34% of the children in this group reported that at home they spoke mainly English, 27% that they spoke mainly Greek and 39% used both languages.

Independent t-tests were used to test for differences in reading and spelling scores between the bilingual and monolingual children. In relation to the scores for English reading and spelling, the bilingual children performed at comparable level to the monolingual English group in all but regular word and non-word reading, where their scores were significantly more accurate, $t(64)=2.0$, $p<.05$, $r=.24$ and $t(64)=2.6$, $p<.01$, $r=.30$, respectively. The advantage for sublexical reading processes reflected in these scores could relate to the fact that the bilingual children were learning a transparent L2 that facilitates the development of sublexical skills (see for example Gupta & Jamal's (2007) study in Chapter 7).

In relation to the scores for Greek reading and spelling, the bilingual children performed significantly worse than the monolingual Greek group in all the assessments except non-word reading. As noted earlier, this overall lower level of literacy skills in the bilingual group is due to the fact that the group comprised emergent bilinguals, living in the UK and learning Greek as a second language. There were significant differences (in favour of the monolingual Greek group) in spelling the 60-word list, $t(72)=7.04$, $p<.0001$, $r=.40$, in the Mouzaki et al. spelling test, $t(60.7)=6.03$, $p<.0001$, $r=.61$, in reading accuracy on the 60-word list, $t(44.2)=3.2$, $p<.001$, $r=.43$, and the Loizidou et al. real words, $t(51.1)=2.5$, $p<.05$, $r=.33$. Significant differences are marked in table 3 with asterisks.

Table 3: *Mean age, non-verbal reasoning and scores for spelling and reading for the monolingual and bilingual younger groups in Study 1 (standard deviations are in parentheses)*

English measures		
	Monolinguals (*N*:31)	Bilinguals (*N*:35)
Age (in years)	7;07 (0;05)	7;09 (0;04)
Non-verbal reasoning[α] (standard score)	113 (12.8)	108 (11.6)
Spelling[β] (standard score)	103 (16)	104 (18)
Spelling accuracy[c] (% correct)	52.6 (23)	55.3 (17.8)
Reading accuracy[c] (% correct)	81 (20.5)	85.1 (17)
Irregular Reading[d] (% correct)	65.6 (19.3)	67.6 (17)
Regular Reading[d] (% correct)	72* (18.6)	81 (16.3)
Non-word Reading[d] (% correct)	56.3** (24)	71.6 (22)
Greek measures		
	Monolinguals (*N*:39)	
Age (in years)	7;08 (0;04)	7;09 (0;04)
Non-verbal reasoning[α] (standard score)	108 (12.3)	108 (11.6)
Spelling[e] (standard score)	109**** (28)	81 (18)
Spelling accuracy[f] (% correct)	61.3**** (18.6)	34.2 (15)
Reading Accuracy[f] (% correct)	95*** (7.1)	83.6 (21.8)
Reading Accuracy[g] (% correct)	92.5* (9.7)	83 (19)
Non-word Reading[g] (% correct)	80 (22.7)	78.4 (25)

Note: [α]Matrix Analogies Test (Naglieri, 1985), [β]WIAT-II, Teacher's edition, spelling subtest (Wechsler, 2006), [c]60-word list (Masterson et al., 2008), [d]DTWRP (Forum for Research in Language and Literacy, 2012), [e]Mouzaki et al. (2007), [f] 60-word list spelling and reading translated in Greek (ibid.), [g]list from Loizidou et al. (2009), * $p<.05$, ** $p<.01$, *** $p<.001$, **** $p<.0001$, p values refer to comparisons between monolinguals and bilinguals

Older group

Monolingual English-speaking children

There were 34 monolingual English-speaking children from Years 4 to 6 (mean age 9;03, *SD*=0;05, range 8;07-10;03), of whom 23 were girls. The children were recruited from the same schools as the younger monolingual English group. No significant differences in results across the schools were observed. Results of the language experience questionnaire revealed that all the children reported they spoke only English at home. Table 4 gives a summary of the background assessment scores for the older monolingual groups and the bilingual group.

Monolingual Greek-speaking children

There were 33 older monolingual Greek-speaking children (mean age 9;03, *SD*=0;06, range 8;03-9;08), 15 of whom were girls. They were recruited from the same schools as the younger monolingual Greek group and matched in age and non-verbal ability to the older monolingual English group. No significant differences in results across the schools were observed. Results of the language experience questionnaire revealed that they spoke only Greek at home.

Bilingual children

There were 44 children in the older bilingual group fromYears 4 to 6 (mean 9;04, *SD*=0;08, range 8;06-11;01), of whom 22 were girls. Fourteen of the children attended a morning Greek independent school and the remainder were recruited from five different Greek afternoon schools in London, UK. No significant differences in results across the schools were observed. The results of the language experience questionnaire revealed that 35% of the participants reported they spoke mainly Greek at home, 38% mainly English, and 27% used both languages.

As for the results for the younger groups, independent t-tests were carried out to test for differences in the reading and spelling scores of the bilingual and monolingual groups. For English reading and spelling, the older bilingual children performed at comparable level to the monolingual English group in all but nonword reading, where their scores were significantly more accurate, $t(76)=2.1$, $p<.05$, $r=.23$. This result was similar to the findings for the younger children, where the bilingual children outperformed the monolingual group in regular word and nonword reading.

In relation to the scores for Greek reading and spelling, these revealed differences in favour of the monolingual group in the Mouzaki et al. spelling test, $t(75)=17.5$, $p<.0001$, $r=.90$, in spelling the 60-word list, $t(74)=15.3$, $p<.0001$, $r=.87$, and in reading the 60-word list, $t(57.3)=6.9$, $p<.001$, $r=.67$. As with the younger bilinguals, this lower level of overall literacy is due to the fact that the children were learning Greek as a second language, thus they were emergent and not balanced bilinguals. Significant differences are marked in table 4 with asterisks.

Table 4: *Mean age, non-verbal reasoning and scores for spelling and reading for the monolingual and bilingual older groups in Study 1 (standard deviations are in parentheses)*

English measures		
	Monolinguals (*N*:34)	Bilinguals (*N*:44)
Age (in years)	9;03 (0;05)	9;04 (0;08)
Non-verbal reasoning$^{\alpha}$ (standard score)	105(14)	105 (15)
Spelling$^{\beta}$ (standard score)	109 (15)	108 (20)
Spelling accuracy^{c} (% correct)	82 (9.4)	81 (9.8)
Reading accuracy^{c} (% correct)	98 (2.1)	98 (1.3)
Irregular Reading^{d} (% correct)	86 (8.9)	89 (5.1)
Regular Reading^{d} (% correct)	92 (6.8)	90 (5.3)
Non-word Reading^{d} (% correct)	81* (13)	87 (11)
Greek measures		
	Monolinguals (*N*:33)	
Age (in years)	9;03 (0;06)	9;04 (0;08)
Non-verbal reasoning$^{\alpha}$ (standard score)	102 (9.8)	105 (15)
Spelling^{e} (standard score)	110**** (22)	82 (19)
Spelling accuracy^{f} (% correct)	73**** (14)	43 (22)
Reading Accuracy^{f} (% correct)	96*** (5.0)	85 (20)
Reading Accuracy^{g} (% correct)	95 (6.3)	88 (19)
Non-word Reading^{g} (% correct)	81 (20)	85 (17)

Note: $^{\alpha}$Matrix Analogies Test (Naglieri, 1985), $^{\beta}$WIAT-II, Teacher's edition, spelling subtest (Wechsler, 2006), ^{c}60-word list (Masterson et al., 2008), ^{d}DTWRP (Forum for Research in Language and Literacy, 2012), ^{e}Mouzaki et al. (2007), ^{f} 60-word list spelling and reading translated in Greek (ibid.), ^{g}list from Loizidou et al. (2009), * p<.05, ** p<.01, *** p<.001, **** p<.0001, p values refer to comparisons between monolinguals and bilinguals

Materials

Non-verbal ability

The Matrix Analogies Test (Naglieri, 1985) assesses non-verbal problem-solving ability. It is for individuals from kindergarten up to all levels of educational attainment and from linguistically and culturally diverse backgrounds as it is culturally neutral and language-free. Consequently, it was appropriate for this cross-linguistic study. The test consists of 35 items. The first is the practice trial; it utilizes shapes and designs. The difficulty increases as the child proceeds through the test. For the purposes of the present study standardised scores were obtained. The test's reliability coefficients are high as most of them ranged around .80.

Measures: Child-related variables

Children were tested individually or in small groups in the standardized and experimental tests.

Spelling

Standarised measures of spelling ability were employed for English and Greek. For English the spelling subtest of the WIAT-II Teachers' Edition (Wechsler, 2006) was used. It is a single word spelling to dictation test with a discontinue criterion of six consecutive errors. The spelling test reliability coefficients range from .93 to.96. For Greek, a single word test developed by Mouzaki et al. (2007) was used. The test was standardized on a sample of 580 Greek students attending Grades 2 to 5. The reliability of the test is α=.91. It has a discontinue criterion of six consecutive errors and maximum score of 60 correct points. Administration of both English and Greek standardized spelling tests involved presentation of the target word followed by a sentence incorporating the target for disambiguation.

For the experimental measure of spelling the 60-word list of Masterson et al. (2008) was used. The English version was translated into Greek for the purposes of the research. Matching on psycholinguistic variables across the two languages was not possible, therefore direct comparisons in spelling performance between the language groups are not performed. Appendix A.2 gives the list of the Greek items. The mean number of letters in the English version is 5.4 (*SD*=1.6) and in the Greek version it is 6.7 (*SD*=1.9). The items cover a wide range of psycholinguistic variables in both Greek and English, and incorporate simple and complex spelling rules and consonant clusters and singletons in both Greek and English. In addition, the referents of the words are known concepts to most children from the age of 6 years. Word frequency values for the items in the English version were obtained from the Children's Printed Word database (Masterson et al., 2003). The mean frequency was 198, *SD*=300. For Greek words, frequency values were obtained by Spencer, Masterson and Syntili (unpublished, also see the stimulus-related variables description later in the text) and their mean frequency was 2.6, *SD*=4.8. A single randomized order for each language version was composed for presentation purposes and the lists were used for spelling to dictation. During testing presentation of the target word was followed by a sentence incorporating the target for disambiguation. Data consisted of the number of items spelt correctly.

Reading

To obtain measures of reading, for English the standardised Diagnostic Test of Word Reading Processes (DTWRP, Forum for Research in Language and Literacy, 2012) was used. In the DTWRP there are 30 regular words, 30 irregular words and 30 nonwords. The DTWRP lists did not differ in number of phonemes, letters and syllables (all Fs<1). The regular and irregular word lists were closely matched for printed word frequency (F<1) using data from the Children's Printed Word database (Masterson et al., 2003). Split half reliability based on a sample of bilingual children for DTWRP regular words was .78, for irregular .82 and nonwords .85. In the absence of an available standardized reading test for Greek at the time the research was conducted the stimuli from Loizidou et al. were adopted (2009). These consist of 40 words and 40 nonwords. Half the items are short (two and three syllables in length) and half long (four and five syllables) in each category. The split-half reliability for the words was .80 and for the nonwords it was .73. In addition, for both English and Greek reading the 60-item list of Masterson et al. (2008) was administered for reading aloud. Data consisted of number of items read correctly. Tests were administered individually.

Phonological ability (PA)

The blending subtest from the Comprehensive Test of Phonological Processing (CTOPP, Wagner, Torgesen, & Rashotte, 1999) was used to assess PA in English. The blending subtest from the Athena Test (Paraskevopoulos, Kalatzi-Azizi, & Giannitsas, 1999) was used to assess PA in Greek. In addition, a spoonerisms task was used. For English, this was the subtest of the Phonological Assessment Battery (Frederickson, Frith, & Reason, 1997). The full spoonerisms test was used where 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/). Items in the

Greek spoonerisms test are included in Appendix A.3. Children were assessed individually and the discontinue criterion was either when 3 minutes passed or when three consecutive incorrect responses were given. Reliability coefficients range for the English task between α=.95-.91 and for the Greek task, based on a sample of bilingual Greek- and English-speaking children, α=.94.

Rapid automatized naming (RAN)

For English, the picture task was used from the Phonological Assessment Battery (Frederickson et al., 1997). Children were asked to name the pictured objects as quickly as possible. The time taken to name all the objects was recorded with a stopwatch. For Greek the same task was used but the children had to name the objects in Greek.

Memory

The following subtests were used from the Athena Test (Paraskevopoulos et al., 1999).

i. *Memory for Digits*

This task taps phonological short-term memory. The researcher read a sequence of digits and the child had to repeat these. The trials became longer as the test proceeded. The child had two opportunities to respond, the first was scored with 2 points, the second with 1, and after two consecutive incorrect responses within a particular string length the test was discontinued. Assessment was individual and lasted three to four minutes. The monolingual English and bilingual children were assessed in English, and the monolingual Greek children in Greek. Total trials correct were calculated for each child and included in the analyses. The maximum correct score was 32 and the test had in total 16 digit sequences.

ii. *Memory for Pictures and Designs*

Two subtests from the Athena Test (Paraskevopoulos et al., 1999) were used, Memory for Designs and Memory for Pictures. These require reproduction, using cards provided by the tester, of a series of either abstract designs (in the Memory for Designs subtest), or familiar pictures, (in the Memory for Pictures subtest). The main difference among the two subtests is that the memory of pictures consists of nine familiar pictures (such as a duck, a bicycle, a house and others), whereas the memory for designs subtest consists of nine abstract geometrical patterns. The child sees a test array and then the tester gives the child the same cards (no distractors) to reproduce the order after five seconds. The number of items presented increases throughout each subtest. Testing begins with three cards in the array 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 as those where the array items are reproduced in the correct order.

Morphological awareness

A word analogy test in English devised by Nunes et al. (2006a) was used. The Greek test was adapted from the Nunes et al. (2006a) task by the researcher, who is an experienced teacher of bilingual and monolingual Greek children, using words that were familiar to the monolingual and bilingual children. Lists of the stimuli in the English and Greek tasks can be found in Appendix A.4. and A.5. The tasks were presented in printed form. The child was asked to provide a spoken answer and then fill the gap with the written stimulus that corresponds to the derivational form of a given word according to a prior example (e.g., *write:wrote, say*:______ correct answer:"said"). Responses were scored for accuracy according to morphology, rather than spelling. The maximum score correct was 8 for both languages. The task involved the past tense but also other grammatical categories. The reliability coefficients based on a sample of bilingual Greek- and English-speaking children for the English task was α=.78 and for the Greek task it was α=.84. The tasks were individually administered.

Receptive Vocabulary

The British Picture Vocabulary Scale, Second Edition (BPVS II; Dunn et al., 1997) was used to assess receptive vocabulary for English. For Greek, the Peabody Picture Vocabulary Test, revised in Greek (Simos et al., 2011) was used. Cronbach α for English is .93 and for Greek .96. The tests were individually administered.

Print exposure

Author and book-title recognition tasks, based on those developed by Cunningham and Stanovich (1992) were used. Those for English were from Rudra (2004). The English test is suitable for primary school children and a similar task was devised in Greek by the researcher suitable for Greek-speaking children of this particular age range. Each task consisted of 35 items, ten of them were foils and 25 were correct. Item correct was calculated by subtracting the foils from the total correct items. Tasks were group administered, presented in printed form, and read aloud by the researcher.

Measures: Stimulus-related variables

Values for the words in the 60-word list on two variables were used in order to examine stimulus-related factors in relation to spelling performance.

Printed word frequency

Values for printed word frequency in children's books for the stimuli were obtained from two language-specific sources. Word frequencies for Greek children's primers were obtained from Spencer, Masterson and Syntili (unpublished). Word frequencies for British English children's books for the age range 5 to 9 years were obtained from the Children's Printed Word Database (Masterson et al., 2003).

Least Transparent Phonographeme Probability

The second set of values obtained for the stimuli concerned transparency of sub-lexical units: Least Transparent Phonographeme (LTPG, see also section 2.4.1. & 3.3.). LTPG values for English for the words in the 60-word list were obtained using Masterson et al.'s (2003) Children's Printed Word Database (Spencer, personal communication). LTPG values for the Greek words were obtained from Spencer et al. (2010).

Ethical considerations

The British Educational Research Association (BERA) ethical guidelines were followed for the research. As the research includes children, prior to any data collection a letter of informed consent was signed by the parents/careers of the pupils. In this, the purpose of the research was clearly stated, also the assessments and the length of the study. The rights of the participants were outlined; specifically, that their participation is voluntary, that they can refuse to answer any questions and that they can withdraw from the study at any time. The information letter emphasized that children's entitlement to confidentiality is totally respected. Finally, the letter explained that at the end of the study a letter outlining the results would be distributed. Prior to any data collection pupils were also informed of the purpose of the study, which assessments would be carried out and their rights. The researcher is experienced in working with children aged 6 to 11 years and took every care to ensure that participating children did not experience stress or fatigue during the assessments. All children were given encouragement and positive feedback at the end of each session.

Procedure

Testing began as soon as ethical approval was obtained from the Institute of Education, University of London Ethics Committee and as soon as letters of informed consent from parents and school authorities were returned. Children were seen in their school individually, or in small groups for tests of spelling and print exposure. Data collection lasted from 2010 to 2012 and different children were assessed every year between the months February to May. Assessments lasted approximately 2 hours for the monolingual children and 4 hours for the bilingual children. Monolingual children were seen for three sessions and bilingual children six sessions in order to avoid fatigue effects. For the bilingual children the different language versions of the same task were always given in separate testing sessions, at least one week apart, and test administration was counterbalanced for language.

Results

For each age and language group correlation analyses and then multiple regression analyses were conducted, using the predictive analytic software PASW 20. The aim was to examine the child- and stimulus-related variables associated with English spelling for the monolingual English and bilingual groups and those associated with Greek spelling for the monolingual Greek group. Descriptive statistics for the scores in the assessments for the different groups are presented first in Tables 5 and 6. Data were checked for normality and variability. WIAT-II spelling results for the younger participants were non-normal, therefore a logarithmic transformation was applied which improved the fit. Thus analysis of the associations was based on the log WIAT-II spelling scores for the English monolingual and bilingual groups. Qualitative analysis of spelling errors in the 60-word list is reported at the end of the Results section.

Table 5: *Mean accuracy for measures of PA, phonological memory, visual memory, morphological awareness, receptive vocabulary and print exposure for the monolingual and bilingual younger groups in Study 1. Scores for RAN involve time to complete the task in seconds (standard deviations are in parentheses)*

	English measures	
	Monolinguals (N=31)	Bilinguals (N=35)
Blending[α] (max= 20)	14.1 (2.5)	13.9 (2.4)
Spoonerisms[β] (max=20)	9.3 (6.1)	9.2 (5.4)
Phonological memory[c] (max=32)	22.8 (5.1)	23.1 (4.9)
Visual Memory Pictures[c] (max=32)	18.4 (5.8)	18.9 (5.3)
Visual Memory Designs[c] (max=32)	13.8 (6.1)	16.1 (5.1)
RAN Pictures[d] (secs)	54.7 (14.4)	58.5 (14.1)
Morphological awareness[e] (max=8)	2.9 (1.4)	2.3 (1.7)
Receptive Vocabulary[f] (max=168)	84.1 (14.6)	80.2 (6.9)
Author recognition[g] (max=25)	6.4 (4.8)	4.9 (3.4)
Title recognition[g] (max=25)	7.2* (4.1)	4.6 (3.7)
	Greek measures	
	Monolinguals(N=39)	
Blending[h] (max= 32)	25 (5.5)	22.4 (2.4)
Spoonerisms[i] (max=20)	11.3 (6.3)	9.4 (6.4)
Phonological memory (max=32)	20.4* (5.8)	23.1 (4.9)
Visual Memory Pictures (max=32)	16.3 (5.9)	18.9 (5.3)
Visual Memory Designs (max=32)	14.7 (5.1)	16.1 (5.1)
RAN Pictures[i] (secs)	57.6**** (15)	87 (27)
Morphological awareness[i] (max=8)	5.1**** (1.8)	2.6 (2.0)
Receptive Vocabulary[j] (max=174)	112**** (12)	48.5 (37)
Author recognition[i] (max=25)	4. 8**** (3.3)	1.2 (1.6)
Title recognition[i] (max=25)	4.4** (2.9)	2.9 (2.5)

Note: [α]CTOPP (Wagner et al., 1999), [β]from PhAB (Frederickson et al., 1997), [c]memory tasks, Athena Test (Paraskevopoulos et al., 1999), [d]from PhAB (ibid.), [e]Morphological awareness (Nunes et al., 2006a), [f]BPVS (Dunn et al., 1997), [g]Rudra (2004), [h]from Athena Test (ibid), [i]devised for Greek according to the equivalent task in English, [j]adapted from PPVT (Simos et al., 2011), *p<.05, **p<.01, ***p<.0001, p values refer to comparisons between monolinguals and bilinguals

Before examining the association of variables with spelling performance, it was considered important to look for differences between the monolingual and bilingual groups in performance on the tasks. Independent t-tests were used for this purpose.

Younger Group

Monolingual English group vs. bilinguals

There were significant differences between the two groups in favour of the monolingual children only in scores for title recognition, $t(54)=2.4$, $p<.05$, $r=.31$. Significant differences are marked in table 5 with asterisks.

Monolingual Greek group vs. bilinguals

A significant difference in favour of the bilingual children was found for phonological memory for digits, $t(72)=2.1$, $p<.05$, $r=.24$. The bilingual children scored lower than the monolingual children in RAN for pictures, $t(53)=5.7$, $p<.0001$, $r=.61$, morphological awareness $t(70)=5.5$, $p<.0001$, $r=.55$, receptive vocabulary $t(41.1)=9.6$, $p<.0001$, $r=.83$, author recognition $t(56)=5.7$, $p<.0001$, $r=.77$, and title recognition $t(68)=2.8$, $p<.01$, $r=.32$. The scores for RAN, morphological awareness, receptive vocabulary and print exposure indicate that the bilingual participants are more skilled in English than they are in Greek, relating to the fact that they live in the UK.

Table 6: *Mean accuracy for measures of PA, phonological memory, visual memory, morphological awareness, receptive vocabulary and print exposure for the monolingual and bilingual older groups in Study 1. Scores for RAN involve time to complete the task in seconds (standard deviations are in parentheses)*

English measures		
	Monolinguals (*N*=34)	Bilinguals (*N*=44)
Blending[α] (max= 20)	14.6 (3.1)	14.8 (3.3)
Spoonerisms[β] (max=20)	14.8 (4.5)	12.7 (4.8)
Phonological memory[c] (max=32)	25.2 (4.4)	25.9 (5.3)
Visual Memory Pictures[c] (max=32)	22.8 (4.8)	22.1 (5.4)
Visual Memory Designs[c] (max=32)	18.4 (5.0)	19.3 (4.7)
RAN Pictures[d] (secs)	45** (10)	52 (12.5)
Morphological awareness[e] (max=8)	4 (2.0)	4.3 (1.7)
Receptive Vocabulary[f] (max=168)	98 (12)	93 (9.9)
Author recognition[g] (max=25)	8.3** (3.1)	6 (3.0)
Title recognition[g](max=25)	11.5*** (3.5)	7.3 (3.2)
Greek measures		
	Monolinguals (*N*=33)	
Blending[h] (max= 32)	26 (5.6)	23 (9.0)
Spoonerisms[i] (max=20)	14 (6.8)	13 (6.5)
Phonological memory (max=32)	20*** (7.1)	25.9 (5.3)
Visual Memory Pictures (max=32)	18.7* (6.1)	22.1 (5.4)
Visual Memory Designs (max=32)	17* (5.4)	19.3 (4.7)
RAN Pictures[i] (secs)	52**** (14)	81 (41)
Morphological awareness[i] (max=8)	5.6**** (2.1)	3.5 (2.4)
Receptive Vocabulary[j] (max=174)	107**** (12)	56.3 (46)
Author recognition[i] (max=25)	5 *** (3.4)	2.1 (3.2)
Title recognition[i] (max=25)	6.5**** (3.3)	3.5 (2.9)

Note: [α]CTOPP (Wagner et al., 1999), [β]from PhAB (Frederickson et al., 1997), [c]memory tasks, Athena Test (Paraskevopoulos et al., 1999), [d]from PhAB (ibid.), [e]Morphological awareness (Nunes et al., 2006a), [f]BPVS (Dunn et al., 1997), [g]Rudra (2004), [h]from Athena Test (ibid), [i]devised for Greek according to the equivalent task in English, [j]adapted from PPVT (Simos et al., 2011), *p<.05, **p<.01, ***p<.001, ****p<.0001, p values refer to comparisons between monolinguals and bilinguals

Older Group

Monolingual English group vs. bilinguals

Monolingual children outperformed the bilingual children in RAN, $t(76)=2.9$, $p<.01$, $r=.31$, author recognition, $t(67)=3.1$, $p<.01$, $r=.35$, and title recognition, $t(63)=4.9$,$p<.001$,$r=.52$.

Monolingual Greek group vs. bilinguals

Significant differences in favour of the bilingual children were found for visual memory for pictures, $t(71)=2.4$, $p<.05$, $r=.27$, visual memory for designs, $t(71)=2.2$, $p<.05$, $r=.25$, and phonological memory, $t(50.2)=3.6$, $p<.001$, $r=.45$. Significant differences in favour of the monolingual children were found for RAN, $t(59.3)= 4.2$, $p<.0001$, $r=.48$, receptive vocabulary, $t(52.7)=6.6$, $p<.0001$, $r=.67$, morphological awareneness, $t(73)=4.0$, $p<.0001$, $r=.42$, author recognition, $t(70)=3.6$, $p<.001$, $r=.4$ and title recognition, $t(70)=4.1$, $p<.0001$, $r=.44$. Significant differences are marked in table 6 with asterisks.

Correlational analyses

Correlational analyses of scores for spelling accuracy in the 60-word list and scores in the other tasks were performed for each age and language group controlling for age. Correlation matrices are provided in Tables 7 to 12. The scores for reading were not considered in the analyses due to ceiling effects. Significant correlations were obtained between scores in spelling the 60-word list and the standardized spelling measure for all groups. This is not mentioned below since it was to be expected.

Younger group

Monolingual English group

Significant partial correlations with spelling scores were observed for all measures, except spoonerisms, RAN, visual memory for designs, and author recognition (see Table 7).

Table 7: *Partial correlations between spelling accuracy in English in the 60-word list and other measures for the younger monolingual group in Study 1*

	1	2	3	4	5	6	7	8	9	10	11	12
Spelling	-											
Non-verbal reasoning	**.51****	-										
Blending	**.43***	.21	-									
Spoonerisms	.34	.16	.19	-								
Phonological memory	**.58*****	.32	.14	**.54****	-							
Visual memory Pictures	**.39***	.31	.26	.05	.14	-						
Visual memory Designs	.23	**.45***	.37	-.09	.07	.22	-					
RAN Pictures	-.24	-.22	.14	-.00	-.09	-.25	-.06	-				
Morphological awareness	**.48****	.26	.10	**.46***	**.42***	.24	.22	-.34	-			
Receptive Vocabulary	**.37***	**.41***	.21	-.02	.05	.19	.23	**-.43***	.30	-		
Author recognition	.22	.02	.09	-.08	.21	.10	-.27	.15	-.02	.12	-	
Title recognition	**.38***	.14	.28	-.09	.06	.29	-.04	-.11	.11	**.44***	**.78*****	-

Note: *p<.05, **p<.01, ***p<.001

Monolingual Greek group

Significant correlations with spelling scores were observed for all measures except non-verbal ability, visual memory for designs (although it approached significance p=.06) and print exposure.[2] The correlations are reported in Table 8.

Table 8: *Partial correlations between spelling accuracy in Greek in the 60-word list and other measures for the younger monolingual group in Study 1*

	1	2	3	4	5	6	7	8	9	10	11	12
Spelling	-											
Non-verbal reasoning	.33	-										
Blending	**.53*****	**.58******	-									
Spoonerisms	**.45****	**.46****	**.45****	-								
Phonological memory	**.53****	**.48****	**.49****	**.40***	-							
Visual memory Pictures	**.49****	.26	**.35***	.23	**.52****	-						
Visual memory Designs	.32	.16	.10	-.10	.23	**.51****	-					
RAN Pictures	**-.37***	-.26	-.09	-.09	-.27	-.32	-.19	-				
Morphological awareness	**.77******	**.43***	**.49****	.26	**.52****	**.41***	**.52****	-.19	-			
Receptive Vocabulary	**.51****	**.38***	.24	.13	**.35***	.16	-.05	-.21	**.38***	-		
Author recognition	.19	**.41***	.26	.18	.32	.29	.02	-.26	.15	.20	-	
Title recognition	.06	.28	**.45****	.02	.34	.30	.15	.04	.11	.18	**.54*****	-

Note:*p<.05, **p<.01, ***p<.001, ****p<.0001

[2] Correlations were also observed with all reading measures, however the associations were lower for Greek than English. For English the correlations ranged between r=.86-.41, p<.0001-p<.05, whereas for Greek they ranged between r=.73-.34, p<.01-p>.05. This could be attributed to ceiling effects due to orthographic transparency.

Bilingual group

Table 9 presents partial correlations among the variables. Significant correlations between scores for spelling in English and blending, spoonerisms and phonological short-term memory were observed. All other associations were not significant. The main difference observed between the results for the bilingual children and monolingual English children was that lexically related variables (such as vocabulary awareness, visual memory for pictures and title recognition) were associated with spelling scores in the monolingual group but not in the bilingual group.

Table 9: *Partial correlations between spelling accuracy in English in the 60-word list and other measures for the younger bilingual children in Study 1*

	1	2	3	4	5	6	7	8	9	10	11	12
Spelling	-											
Non-verbal reasoning	.03	-										
Blending	**.56****	.26										
Spoonerisms	**.45***	-.09	.08	-								
Phonological memory	**.52***	-.04	**.43***	**.51***	-							
Visual memory Pictures	.19	-.25	-.01	.30	.15	-						
Visual memory Designs	.24	-.10	-.11	.38	.38	**.55***	-					
RAN Pictures	-.34	-.19	-.14	.08	-.08	-.11	-.21	-				
Morphological awareness	.30	.02	-.15	**.48***	.27	.18	**.52***	**-.44***	-			
Receptive Vocabulary	.29	-.05	.14	.17	.08	**.46***	.13	.14	-.36	-		
Author recognition	-.10	.42	-.27	-.26	**-.46***	-.29	-.27	-.18	-.19	.19	-	
Title recognition	-.22	.28	-.38	-.26	-.33	-.26	.27	-.09	.03	-.29	.43	-

Note:*p<.05, **p<.01

Older Group

Monolingual English group

Significant correlations between scores for spelling and those for visual memory for pictures, RAN and author and title recognition were found. This suggests that RAN plays a more significant role for spelling at an older than a younger age for the English children. Neither phonological nor morphological awareness were associated with spelling for this older group, while both were for the younger monolingual English group. Table 10 presents the correlations.

Table 10: *Partial correlations between spelling accuracy in English in the 60-word list and other measures for the older monolingual group in Study 1*

	1	2	3	4	5	6	7	8	9	10	11	12
Spelling	-											
Non-verbal reasoning	.49**	-										
Blending	.36	.11	-									
Spoonerisms	.21	.24	-.03	-								
Phonological memory	.31	.31	.31	.53**	-							
Visual memory Pictures	.62***	.51**	.03	.47*	.50**	-						
Visual memory Designs	.14	.27	-.24	.30	.32	.29	-					
RAN Pictures	-.37*	-.63***	.13	-.14	-.17	-.52**	-.32	-				
Morphological awareness	.14	.11	-.09	.11	.21	.27	.10	-.33	-			
Receptive Vocabulary	.25	-.04	.10	.09	.30	.31	.07	-.12	.26	-		
Author recognition	.50**	.30	.22	.28	.17	.38*	.03	-.19	.24	.42*	-	
Title recognition	.51**	.02	.24	.06	.12	.32	.11	.04	.44*	.13	.64***	-

Note:**p*<.05, ***p*<.01, ****p*<.001

Monolingual Greek group

Significant correlations were observed between spelling scores and morphological awareness, phonological memory, receptive vocabulary and visual memory for designs. Table 11 presents the correlations between the variables. The main difference in comparison with the younger monolingual Greek children is that RAN was significantly associated with spelling performance for the younger children but not the older children. The main difference in comparison with the older monolingual English group is that phonological memory and morphological awareness were associated with spelling in Greek in the Greek monolinguals but not with spelling in English in the English monolinguals.

Table 11: *Partial correlations between spelling accuracy in Greek in the 60-word list and other measures for the older monolingual group in Study 1*

	1	2	3	4	5	6	7	8	9	10	11	12
Spelling	-											
Non-verbal reasoning	.42	-										
Blending	.35	.28	-									
Spoonerisms	.38	-.07	.22	-								
Phonological memory	.63*	.43	.61*	.10	-							
Visual memory Pictures	.48	.60*	.45	.26	.59*	-						
Visual memory Designs	.70**	.69*	.17	.31	.68**	.72**	-					
RAN Pictures	-.41	-.38	-.53	-.49	-.44	-.61*	-.60*	-				
Morphological awareness	.57*	.21	.26	.23	.65*	.47	.57*	-.50	-			
Receptive Vocabulary	76**	.05	.15	.56*	.44	.08	.49	-.40	.46	-		
Author recognition	.31	.04	.03	-.24	.39	-.00	.30	-.15	.25	.46	-	
Title recognition	.32	.56	.40	.21	.63*	.32	.57*	-.27	.19	.29	.33	-

Note:**p*<.05, ***p*<.01

Bilingual group

Spelling scores for English were significantly correlated only with those for receptive vocabulary, and memory for digits approached significance (r=.38, p=.070). Table 12 presents the correlations between measures.

Table 12: *Partial correlations between spelling accuracy in English in the 60-word list and other measures for the older bilingual group in Study 1*

	1	2	3	4	5	6	7	8	9	10	11	12
Spelling	-											
Non-verbal reasoning	.38	-										
Blending	.21	-.07	-									
Spoonerisms	.27	.01	.02	-								
Phonological memory	.38	**.54****	-.03	.35	-							
Visual memory Pictures	.18	.37	-.24	-.06	**.44***	-						
Visual memory Designs	.06	**.57****	-.26	.20	.31	.30	-					
RAN Pictures	-.19	-.01	-.14	.11	.03	-.24	.03	-				
Morphological awareness	.10	.08	.07	.20	.02	-.28	-.29	-.09	-			
Receptive Vocabulary	**.54****	.39	.21	**.50***	.25	.19	.27	-.01	.08	-		
Author recognition	.16	-.04	.12	.15	.07	.23	.25	-.09	-.16	.35	-	
Title recognition	.21	.08	.24	.12	.15	**.40***	-.06	-.41*	.06	.20	**.49***	-

Note:*p<.05, ** p<.01, ***p<.001

Summary of correlation analyses

Table 13 presents the partial correlations between spelling scores and the different variables for the three groups when taking into account age.

Table 13: *Partial correlations between spelling accuracy in the 60-word list and other measures across the different groups in Study 1 (English for the monolingual English and the bilingual groups and Greek for the monolingual Greek group)*

	Monolingual English		Monolingual Greek		Bilingual	
Group	Young	Old	Young	Old	Young	Old
Non-verbal reasoning	**.51****	**.49****	.33	.42	.03	.38
Blending	**.43***	.36	**.53*****	.35	**.56****	.21
Spoonerisms	.34	.21	**.45****	.38	**.45***	.27
Phonological memory	**.58*****	.31	**.53****	**.63***	**.52***	.38
Visual memory for Pictures	**.39***	**.62*****	**.49****	.48	.19	.18
Visual memory for Designs	.23	.14	.32	**.70****	.24	.06
RAN Pictures	-.24	**-.37***	**-.37***	-.41	-.34	-.19
Morphological awareness	**.48****	.14	**.77*******	**.57***	.30	.10
Receptive Vocabulary	**.37***	.25	**.51****	**76****	.29	**.54****
Author recognition	.22	**.50****	.19	.31	-.10	.16
Title recognition	**.38***	**.51****	.06	.32	-.22	.21

Note:**p*<.05, ** *p*<.01, ****p*<.001

From the correlations, controlling for age, presented above we can see that non-verbal reasoning exerts an influence on spelling for the English monolingual children but not for the Greek monolingual children or the bilingual children. Phonological processing (as reflected in blending and phonological memory tasks) was significantly ssociated with spelling for all three younger groups. The spoonerisms task was significantly associated with spelling skill of the young monolingual Greek and bilingual English and Greek speaking children but not with spelling skill of the monolingual English speaking children. However, for the monolingual older English group the association is not observed. This is in contrast to the monolingual Greek speaking children’s performance where phonological memory correlates with spelling skill, but not with the bilingual children’s performance. Comparisons between the phonological processing correlations coefficients of the monolingual English and Greek speaking groups indicate that for the younger participants there is no significant difference in the correlation coefficients for all three phonological processing tasks between the two monolingual groups. However, for the older monolingual groups a significant difference was found between the two different coefficients obtained for phonological memory, χ^2=2.7, p=.05, with the coefficient being larger for the monolingual Greek participants.

For the English monolingual participants visual memory for pictures was found to be strongly associated with English spelling whereas the coefficient between visual memory for designs and spelling was not found significant. For the Greek young participants, visual memory for pictures was strongly related to spelling skill, whereas for the older children the coefficient of visual memory for designs and spelling was more significant. For the young English and Greek monolingual groups comparisons of the correlation coefficients between visual memory and spelling and phonological processing and spelling were not significant. However, for the old English monolingual group comparison of the correlation coefficients between spoonerism and spelling were weaker than the relationship between visual memory for pictures and spelling, Pearson-Fillon Z=-2.01 p(two sided)= .03. Similar result was observed between blending and spelling and visual memory for designs and spelling for the older Greek monolingual participants, the association was stronger for the latter pair Pearson-Fillon Z=-1.9, p(two sided)= .04.

Another point of interest is that morphological awareness and vocabulary are only important for the young monolingual English-speaking children whereas for both groups of monolingual Greek-speaking children morphological awareness and vocabulary were associated with spelling skill. This comes in sharp contrast with Garcia et al.'s (2010) finding that MA is more significantly associated with older children's spelling performance. This difference might be due to the fact that we controlled for age and due to the fact that Garcia et al.'s MA task included also a syntactic component. One should also point out title recognition is only important for English spelling of monolingual (younger and older) children after controlling for age. Finally, RAN seems to be important for older English-speaking children whereas the opposite is observed for the Greek speaking children, where RAN is more significantly associated with spelling scores of the younger children.

Finally, for the bilingual children phonological processing seems to be strongly associated with spelling of the younger children, whereas for the older children vocabulary is the most significant associate.

Regression analyses

Simultaneous multiple regression analyses were conducted in order to look for indications of difference in pattern of reliance on lexical or sublexical processing for spelling across the language and age groups in Study 1. Analyses involving child-related variables are presented first, followed by those involving stimulus-related variables. The criterion variable was spelling scores in the 60-word list, in English for the monolingual English and bilingual children, and in Greek for the monolingual Greek children. In the regression analyses involving child-related variables, the data for the criterion variable consisted of total correct responses in the 60-word list per child, calculated across items. In the regression analyses involving stimulus-related variables, the criterion variable consisted of correct responses per word in the 60-word list, calculated across participants.

For the child-related analyses there were two predictor variables. The first consisted of scores for visual memory, as a potential indictor of use of whole-word lexical processes in spelling, and the second was scores for phonological ability, as a potential indicator of the use of sublexical processes. Principal component analysis was conducted and a single combined score was derived from the two different visual memory assessments (Memory for Pictures and Memory for Designs), as significant correlations were observed for scores on the two subtasks. For phonological ability also principal component analyses indicated use of a single combined score from the two phonological ability tasks (spoonerisms and blending). The aim in using these variables was to be consistent with the analyses carried out by Masterson et al. (2008). These authors found evidence for differential reliance on lexical and sublexical processes in spelling in monolingual English and Greek children. Also, Mumtaz and Humphreys (2001, 2002) found evidence of differential reliance on lexical or sublexical processing for reading in English depending on bilingual children's level of knowledge of transparent Urdu.

In summary, the criterion variable in the first set of analyses was spelling scores per child in the 60-word list, and predictor variables were visual memory and phonological ability combined score. Results of the regression analyses for the monolingual younger and older children are presented first, followed by those for the bilingual younger and older children.

Results of regression analyses with child-related variables

Younger group

Monolingual children

The results are summarised in Table 14 for all the groups.

Table 14: *Simultaneous multiple regression analyses with spelling accuracy across items in the 60-word list as the dependent variable for the monolingual and bilingual younger and older groups in Study 1*

	English spelling							
	Monolingual younger				*Bilingual younger*			
	B[a]	SE[b]	β[c]	R^2	B[a]	SE[b]	β[c]	R^2
Visual memory	4.9	2.1	**.36***	**.38**	1.7	1.5	.17	**.31**
Phonological ability	5.4	1.9	**.42***		5.5	1.6	**.51****	
	Monolingual older				*Bilingual older*			
Visual memory	2.1	.83	**.41****	**.34**	2.0	.80	**.32***	**.45**
Phonological ability	1.8	.94	.31		3.0	.70	**.54***	
	Greek spelling							
	Monolingual younger							
Visual memory	3.3	1.4	**.28***	**.45**				
Phonological ability	6.6	1.5	**.55******					
	Monolingual older							
Visual memory	5.6	1.8	**.47****	**.55**				
Phonological ability	5.6	2.2	**.39***					

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, *p<.05,**p<.01, **** p<.0001

Both visual memory and phonological ability were significant predictors for the younger monolingual English children's spelling. The overall regression model was significant, $F(2,28)=8.6$, $p<.001$. Visual memory combined score accounted for 22% of variance in English spelling, whereas phonological ability accounted for 27% of variance. Phonological ability and visual memory were also significant predictors of the monolingual Greek younger children's spelling performanc The overall regression model was significant, $F(2,34)=13.9$, $p<.0001$. Phonological ability accounted for 37% of variance in Greek spelling, and visual memory accounted for 17% of variance.

Bilingual children

Only phonological ability was a significant predictor of the bilingual group's spelling in English. The overall regression was significant, $F(2,32)=7.2$, $p<.01$. Visual memory accounted for .05% of variance and phonological ability for 28% of variance.

Older group

Monolingual children

Only visual memory was a significant predictor of spelling for the older English monolingual children. The overall regression model was significant, $F(2,31)=6.6$, $p<.01$. Visual memory accounted for 25% and phonological ability for 18% of variance. Both visual memory and phonological ability were significant predictors of spelling for the older Greek monolingual children. The overall regression model was significant, $F(2,26)=14.8$, $p<.0001$. Visual memory accounted for 43% and phonological ability for 38% of variance.

Bilingual children

Both visual memory and phonological ability (tested in English) were significant predictors of spelling for the older bilingual children. The overall regression was significant, $F(2,38)=14.5$, $p<.0001$. Visual memory accounted for 16% of variance and phonological ability for 35% of variance.

Summary of results of regression analyses with child-related variables

The results from the regression analyses revealed that, for English spelling, both visual memory and phonological ability were significant predictors for the younger (seven-year-old) monolingual children. For the older (nine-year-old) monolingual children only visual memory was a significant predictor, suggesting that whole word lexical processes may become more prominent for spelling with age. For Greek spelling, the results for both the monolingual younger and older children revealed that both phonological ability and visual memory were significant predictors of Greek spelling; however, older children's spelling was more strongly predicted by visual memory than phonological ability. This could indicate that the arbitrariness of Greek spelling leads children, at a later stage of development, to begin to rely more heavily on lexical processes for spelling although sublexical processes are also apparent. For bilingual younger children only phonological ability was a significant predictor of English spelling and for older children both phonological ability and visual memory were significant predictors. This suggests that the transparency of Greek leads bilingual children to rely on sublexical processing for spelling at an early age and both lexical and sublexical processes at a later age. This result is in agreement with Mumtaz and Humphreys (2001, 2002) findings for reading, suggesting that transfer of processing occurs from one language to the other, and that the degree of transparency of the language leads to emphasis on lexical or sublexical processes. The findings are also in agreement with DR models of spelling (e.g., Barry, 1994), which suggest that both lexical and sublexical processes are important for competent spelling. Finally, the results indicate that the transparency of each language and the age of the participants affect the influence of each variable. The results indicated that for both Greek and English spelling older children showed more of an influence of visual/lexical processes, although for Greek spelling phonological processes are also important. In the next section regression analyses based on stimulus-related variables will be presented.

Results of regression analyses with stimulus-related variables as predictors

Separate simultaneous multiple regression analyses were conducted for each group with the item data (number of correct spelling responses per item in the 60-word list calculated across participants) as the criterion variable. The stimulus-related variables of printed word frequency (employed as a potential indicator of use of whole word lexical processes for spelling) and least transparent phonographeme probability (LTPG) (used as a potential indicator of use of sublexical processes) were predictors. Prior to the analyses the data were checked for normality. A logarithmic transformation improved the fit of frequency; consequently, analyses reported are based on the log frequency values.

Younger group

Monolingual children

A summary of the results is provided in Table 15.

Table 15: *Simultaneous multiple regression analyses with spelling accuracy across participants in the 60-word list as the dependent variable for the monolingual and bilingual younger and older groups in Study 1*

	English spelling							
	Monolingual younger				*Bilingual younger*			
	B[a]	SE[b]	β[c]	R^2	B[a]	SE[b]	β[c]	R^2
Frequency	6.7	1.4	**.47******	**.44**	8.5	1.7	**.51******	**.43**
LTPG	988	234	**.42******		1035	281	**.37*****	
	Monolingual older				*Bilingual older*			
Frequency	5.4	1.6	**.39*****	**.21**	7.8	2.0	**.44******	**.28**
LTPG	460	270	.20		745	333	**.25***	
	Greek spelling							
	Monolingual younger							
Frequency	0.6	0.3	**.28***	**.37**				
LTPG	499	185	**.32****					
	Monolingual older							
Frequency	0.5	0.2	**.29****	**.34**				
LTPG	372	150	**.30****					

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, **p*<.05,***p*<.01, ****p*<.001, *****p*<.001

The overall regression model was significant for the monolingual English group, $F(2,57)=22.1$, $p<.0001$, and for the monolingual Greek group, $F(2,57)=7.6$, $p<.001$. Both printed word frequency and LTPG were significant predictors of spelling accuracy for both monolingual groups. For the monolingual English group, printed word frequency explained 26% of variance and LTPG 21% of variance. For the monolingual Greek group, printed word frequency explained 7% of variance and LTPG 14% of variance.

Bilingual children

The overall regression model was significant for the bilingual group, $F(2,57)=21$, $p<.0001$. Both printed word frequency and LTPG were significant predictors of spelling accuracy. Printed word frequency accounted for 29% of variance and LTPG for 17% of variance.

Older group

Monolingual children

The overall regression model was significant for the older monolingual English group $F(2,57)=7.6$, $p<.001$, and for the monolingual Greek group, $F(2,57)=7.04$, $p<.01$. Printed word frequency, and not LTPG was a significant predictor of spelling accuracy for monolingual English-speaking children. Both printed word frequency and LTPG were significant predictors of spelling accuracy for the monolingual Greek group. For the monolingual English group, printed word frequency explained 17% of variance and LTPG 5% of variance. For the monolingual Greek-speaking group, printed word frequency explained 9% of variance and LTPG 11% of variance.

Bilingual children

The overall regression model was significant for the bilingual group, $F(2,59)=10.9$, $p<.0001$. Both printed word frequency and LTPG were significant predictors, the former accounted for 20% of variance and the latter 10% of variance.

Summary of results of regression analyses with stimulus-related variables

The finding that both word frequency and LTPG predicted the spelling performance of the young monolingual English group is in line with the results obtained by Spencer (2007) with English-speaking children, indicating the use of both lexical and sublexical processing for spelling. The results for the older children for English spelling, where word frequency but not LTPG was a significant predictor, seem to indicate that there is more involvement of lexical than sublexical processes in spelling as children grow older. This is in agreement with the analyses of the child-related variables, where visual memory and not PA was the strongest predictor of spelling for the older English monolingual children. The results for the monolingual Greek children, on the other hand, indicate reliance on sublexical processes for spelling since LTPG was a significant predictor for both young and older children. Visual memory was also a significant predictor for the younger and older children, indicating reliance on lexical processing as well. The bilingual children, both younger and older, seem to rely on both lexical and sublexical processes as was also found in the analyses involving the child-related variables. This would seem to be in line with the fact that they were learning to read and spell in a transparent as well as an opaque writing system (see also relevant discussion in section 7.1.2., in the study of Hanley et al., 2004; Gupta & Jamal, 2007). We might have expected to observe that the monolingual Greek group would show less evidence of use of lexical processing; however, they appear to use both lexical and sublexical processing, which corroborates findings from previous studies carried out in transparent writing systems (e.g., Zoccolotti et al., 2009; Loizidou et al., 2009, covered in the literature section 2.4.1. & 3.3.).

Qualitative analysis of spelling errors

A qualitative analysis of the children's misspellings in the 60-word list was conducted. Errors were divided into two categories:

1. Phonologically appropriate errors, which involved retaining the correct phonology, but where the spelling was incorrect (for example, *elephant*> ELEFANT).
2. Non-phonologically appropriate errors, where the misspelled word did not appear to retain the phonology of the target (for example, *monastery*> MONASTREET).

Percentages of each category of error were calculated for the groups separately.

Younger group

The monolingual English speaking children made an average of 64% (*SD*=21) phonologically appropriate errors, while monolingual Greek participants made an average of 93% (*SD*=11) phonologically appropriate errors. The bilingual children made 67% (*SD*=12) phonologically appropriate errors. Independent t-test conducted indicated that the difference in phonologically appropriate errors between the English monolingual children and the bilingual children was not statistically significant (p>.5).

Older group

The monolingual English children made an average of 68% (*SD*=26) phonologically appropriate errors, while monolingual Greek children made an average of 95% (*SD*=9) phonologically appropriate errors. The bilingual children performed similarly to the monolingual English group as they made 64% (*SD*=20) phonologically appropriate errors.

Discussion

Study 1 aimed to investigate associations between single word spelling and a range of psycholinguistic variables in typically developing monolingual and bilingual Greek- and English-speaking children. It also aimed to investigate possible transfer effects. It was expected that the variables might show different levels of association with spelling depending on the transparency of the writing system, with lexically-related variables being more highly associated with spelling in opaque English and sublexically-related variables being more highly associated with spelling in transparent Greek.

The study initially used partial correlations (controlling for age) to investigate the association of spelling performance in the 60-word list from Masterson et al. (2008) and a set of psycholinguistic variables tapping PA, phonological memory, visual memory, RAN, receptive vocabulary, morphological awareness and print exposure in groups of monolingual and bilingual English- and Greek-speaking children aged seven and nine.

Associations between single word spelling and child-related variables

English spelling

The results revealed that the younger English children's spelling was associated with all measures apart from spoonerisms, RAN, visual memory for designs and author recognition. Cunningham and Stanovich (1993) also reported an association between print exposure and spelling skill in children of comparable age to the younger children in the present study. The younger bilingual children's English spelling performance was significantly associated only with the three variables tapping phonological processing.

Older monolingual English-speaking children's spelling performance was associated with RAN. This finding is in agreement with Cardoso-Martins and Pennington (2004) who found that RAN is associated with later spelling performance of English speaking children. Ziegler et al. (2010a) claim that this is found because performance in PA tasks approaches ceiling, leaving more variance to be predicted by other variables such as RAN. However, this was not the case in the present study as PA scores were not at ceiling. Another finding of note is that spelling performance of older monolingual English children was not associated with either of the PA tasks or phonological memory, and this was different from the results for the younger monolingual English children. Unlike the older monolingual children, older bilingual children's spelling was not significantly associated with RAN. On the other hand, this group's spelling performance was significantly associated only with receptive vocabulary. Correlations between receptive vocabulary and English spelling performance were observed for younger monolingual and older bilingual children. This finding supports the results of Cunningham and Stanovich (1991) who reported significant correlations between vocabulary and spelling. Print exposure seemed to exert a more significant role for monolingual rather than bilingual children. For the older children both measures of print exposure were significantly associated with spelling. This could indicate that as children get older they rely more on information obtained through exposure to printed words than on phonological decoding. It was also of note that morphological awareness was more highly associated with young monolingual and bilingual children's spelling than older monolingual and bilingual children's spelling.

Greek spelling

Spelling performance in Greek was associated for both the younger and older children with PA, phonological memory, visual memory for pictures and designs, RAN, morphological awareness and receptive vocabulary. The association between spelling and scores for blending, spoonerisms and phonological memory was higher than the association between RAN and spelling, and the difference was significant for both groups ($z_{younger}=5.00$, $p<.0001$, $z_{older}=5.8$, $p<0001$). Moll and Landerl (2009) and Nikolopoulos et al. (2006) also reported that the association between RAN and spelling was not a strong one for a transparent orthography. RAN was not significantly associated with blending, spoonerisms and phonological memory for the younger and older monolingual participants. This comes in agreement with previous findings suggesting that RAN is not phonologically mediated (Stainthorp et al., 2013). A significant association between vocabulary and spelling was detected for both the

English and Greek monolingual groups. This runs contrary to Share's (2008) claim that lexical variables, such as vocabulary, are less associated with transparent orthographies which rely strongly on sublexical processes. Finally, in contrast to the result for older English monolinguals, morphological awareness was significantly associated with Greek spelling for both younger and older children. This likely relates to the fact that Greek is a highly inflected language. This finding is congruent with the findings of Aidinis (1989) for Greek monolingual participants.

Lexical and sublexical processes

The aim was to investigate in monolingual Greek and English children whether or not evidence could be found for a difference in reliance on lexical or sublexical processes in spelling. Therefore, phonological ability, a child-related variable associated with sublexical processing, and visual memory, a child-related variable considered to be associated with lexical processes (see section 3.2.for a review) were investigated in the regression model in relation to spelling performance. For monolingual English younger (seven-year-old) children both phonological ability and visual memory were found to be associated with spelling. For monolingual English older (nine-year-old) children only visual memory was found to be a significant predictor. The finding suggests that as children get older there is stronger reliance on lexical processes. This is also in agreement with the finding in the correlation analyses of a strong association of spelling scores with print exposure (as well as visual memory) for the monolingual English older children, and lack of a significant association with PA scores or phonological memory in this group.

For Greek spelling a similar pattern emerged from the regression analyses to the findings from the monolingual English younger children. Younger and older monolingual Greek children's spelling scores were predicted by both phonological ability and visual memory. The only difference of note was that for young Greek monolingual children phonological ability was more strongly associated with spelling ($p<.0001$) than visual memory ($p<.05$), while for old Greek monolingual children the opposite was the case. The findings for the Greek children indicate that both lexical and sublexical processes play a significant role in spelling. This corroborates findings from Loizidou et al.'s (2009) cross-sectional study (see section 2.4.1. & 3.3. for a review). Those authors observed that both lexical and sublexical variables predicted Greek children's spelling skill at an older age.

Regression analyses were also conducted with item data and stimulus-related predictor variables. Printed word frequency was the stimulus-related variable associated with lexical processing and LTPG was the variable associated with sublexical processing. For the younger monolingual English children both these variables were significant predictors of spelling scores, but for the older children only frequency remained significant. For the Greek children the pattern across age was different, since frequency and LTPG were significant predictors at both ages. These results suggest that sublexical processing continues to play a stronger role in spelling even in more experienced spellers, than is the case for English.

The results for Greek spelling indicate that both lexical and sublexical processing are employed by children. The findings seem to be in opposition to arguments that for reading and spelling in transparent orthographies children rely heavily on sublexical processing (Share, 2008 for reading; Nikolopoulos et al. 2003, Nikolopoulos et al., 2006 for spelling, see section 3.2. & 3.3. for a review). However, as noted above, they are in agreement with the findings of Loizidou et al. (2009), and could be due to the fact that Greek is transparent for reading but inconsistent for spelling. The results overall indicate similarities in factors that affect spelling in English and Greek, but that characteristics of the orthography regulate the strength of the associations.

Results of qualitative analyses of spelling errors

Finally, the qualitative analyses revealed that monolingual English children, from both age groups, made fewer phonologically appropriate errors than monolingual Greek children. The bilingual children's spelling errors in English contained a similar proportion of phonologically appropriate errors to the English monolingual children.

Transfer effects in spelling

Considering now the results relating to transfer effects, it was found that younger English monolinguals' spelling was predicted by visual memory and phonological ability, indicating that children around the age of seven years rely on both lexical and sublexical processes for spelling. The same result was not detected for English spelling performance of bilingual young participants, as their spelling was predicted only by PA, suggesting a stronger influence of sublexical than lexical processes. The older monolingual English children's spelling was predicted by visual memory; however, the older bilingual children's spelling was predicted by both visual memory and phonological ability. In the regression analyses involving stimulus-related variables, the results of the bilingual children were akin to those of the Greek monolinguals, since their spelling was significantly predicted by both the lexically-related and the sublexically-related variables at both ages. The findings indicate that while the monolingual children seem to use both lexical and sublexical processes for spelling as novice spellers, they come to rely more on lexical processes with age, and this is more pronounced for the English monolinguals than the Greek monolinguals. The bilingual children show strong reliance on sublexical processes as novice spellers, and continue to use sublexical processes, as well as lexical processes with age, likely due to the influence of learning a transparent second language. This is in agreement with other cross-linguistic studies investigating transfer effects in literacy skills (c.f. Abu-Rabia & Siegel, 2002; Hanley et al., 2004; Gupta & Jamal, 2007, described in Chapter 7).

In summary, the findings are consistent with those of other cross-linguistic studies (c.f. Holm & Dodd, 1996; Mumtaz & Humphreys, 2001, 2002) and with the interdependence hypothesis (Cummins, 1981) indicating that strategies involved in acquiring L2 will be transferred to L1.

Interim summary

The results for the younger monolingual Greek- and English-speaking children confirmed the importance of phonological processes in the early stages of spelling acquisition (Caravolas et al., 2001; Porpodas, 1999). With age, however, lexical processes also seemed to play more of an influential role in spelling in both orthographies. These findings suggest that the stumbling blocks faced by English children do not differ from those encountered in other orthographies and that the spelling processes do not greatly differ between the orthographies. This is not different than findings of Georgiou et al. (2012b, see section 3.2.) who found that longitudinal predictors of Greek and English spelling did not differ, as both languages are more difficult to spell than to read. However, characteristics of each writing system seem to affect the influence of lexical and sublexical processes in spelling. In the next studies to be reported (in Study 2) lexically and sublexically-related variables were assessed in bilingual and monolingual English- and Greek-speaking children in relation to spelling, using a longitudinal design. The aim was to further examine transfer effects and to look for evidence of the malleability of developing processes of the spelling system in bilingual children. Bilingual children in Study 2 were divided into groups on the basis of literacy abilities in Greek. The aim was to investigate whether differential reliance on processes for spelling in English would be observed, according to proficiency in Greek.

Chapter 5

5. Transfer effects in spelling from transparent Greek to opaque English[3]

5.1. Study 2a: Time 1 assessment

Introduction

The present study looked for evidence of the transfer of literacy processes used in transparent Greek to spelling in opaque English. The same predictors of spelling performance as had been employed in Study 1 were used in this study. Thus, visual memory and PA were child-related variables and printed word frequency and LTPG were stimulus-related variables. These were examined in relation to spelling in a monolingual sample of English speaking children and a monolingual sample of Greek speaking children. The third sample of children was bilingual in English and Greek. The children were aged on average 7 years and so the sample was comparable in age to the younger children in Study 1. The bilingual children in Study 2 were divided into two groups on the basis of their proficiency in reading and spelling Greek words. It was reasoned, based on evidence from the literature review and findings of the previous study, that for Greek monolingual participants PA would be a strong predictor of spelling, whilst PA and visual memory might be equally strong predictors of spelling performance for monolingual English children. In relation to the bilingual participants, it was predicted that those with a high level of experience in reading and spelling in Greek would show more evidence of influence of sublexically-related variables in their spelling in English. Conversely, those with lower levels of experience of reading and spelling in Greek would show more evidence of the influence of whole-word lexically-based variables. Therefore, in terms of child-based variables, it was expected that PA would be a more robust predictor of English spelling performance than visual memory in the strong Greek group, while for the weak Greek group visual memory and PA would be equally strong predictors. In relation to the stimulus-related variables, it was predicted that the lexically-related variable printed word frequency would be more closely associated with the spelling performance of the monolingual English and weak Greek bilingual groups, and the sublexically-related variable LTPG would be more closely associated with the spelling performance of the monolingual Greek and strong Greek bilingual groups.

[3] Part of the research is presented in a paper in the journal *Bilingualism Language and Cognition* and at a presentation at the Experimental Psychological Society Conference, London 2012.

Finally, qualitative analyses of the children's spelling errors were carried out to investigate the rate of phonologically appropriate errors across the groups. It was predicted that the rate of such errors would be higher in the monolingual Greek and strong Greek bilingual groups than in the monolingual English and weak Greek bilingual groups, since the former groups were expected to be relying more on sublexical processing than the latter, and this would result in a higher incidence of phonologically appropriate errors than use of whole-word processes.

Method

Study 2a involves looking at predictors of accuracy in spelling the 60-word list in English in the monolingual English and bilingual groups and of spelling the 60-word list in Greek in the monolingual Greek group.

Participants

Children in Study 2a were recruited from the same or comparable schools as the children in Study 1. Thus, their experience of literacy instruction was equivalent to that of Study 1 children and their background characteristics were similar to that sample.

Monolingual English group

The monolingual English speaking participants were 33 children attending primary schools in London, UK. Three of the schools were located in North London (students in the bilingual sample also attended these schools) and one school was in inner-London. Of the eighteen children from the North London schools, 15 were girls. The children's ages ranged from 6;09 to 9;00 years (mean=7;09, *SD*=0;07). The chronological ages of the children in the four schools were compared using one-way ANOVA and there was no significant group effect (F<1). In addition, one–way ANOVAs revealed no significant group effect across schools for non-verbal reasoning scores, or reading and spelling accuracy in the assessments described in the next paragraph (all Fs<1). As for the monolingual group in Study 1, literacy instruction in the schools involved a combined whole word and phonics-based approach. All children reported that they were monolingual based on a language experience questionnaire.

The children in this group, and in the monolingual Greek and bilingual groups, were given a single word spelling to dictation task and a single word reading task using the 60-word list taken from Masterson et al. (2008). A description of the tasks is given in Study 1. Data recorded were number of items read and spelt correctly. A non-verbal reasoning test (the Matrix Analogies Test, Short Form, Naglieri, 1985) was also administered to all children, in order to ensure that the groups were matched in terms of general ability. A description of the task is given in Study 1. Table 16 provides a summary of the participants' characteristics.

Table 16: *Summary of participant characteristics for the monolingual and bilingual groups in Study 2a (standard deviations are in parentheses)*

	Monolingual		Bilingual	
	English (*N*:33)	Greek (*N*:36)	Weak Greek (*N*:23)	Strong Greek (*N*:23)
Age (in years)	7;09 (0;06)	8;01 (0;09)	7;09 (0;07)	7;09 (0;06)
Non-verbal reasoning[α] (standard scores)	111 (29)	104 (24)	109 (28)	106 (30)
English reading[b] (% correct)	87 (15)	-	82 (17)	85 (18)
English spelling[b] (% correct)	59 (24)	-	54 (17)	60 (24)
Greek reading[c] (% correct)	-	94 (7.6)	57 (22)	95 (4.6)
Greek spelling[c] (% correct)	-	61 (16)	21 (7.8)	44 (11)

Note: [α]Matrix Analogies Test (Naglieri, 1985), [b]60-word list from Masterson et al. (2008), [c]60-word list (ibid.) translated into Greek

Monolingual Greek group

The participants were 36 monolingual Greek speaking children from Crete. The children were recruited from private and state schools (5 participants attended private school and 13 were girls). Their age ranged from 6;08 to 9;03 (mean=8;01, *SD*=0;09). A summary of the participants' characteristics is given in Table 16. Children were recruited from the same schools that monolingual Greek children in Study 1 came from. Literacy instruction in these schools involved a phonics based approach. All children reported that they were monolinguals based on a language experience questionnaire completed with the help of the author.

Bilingual group

Participants in the bilingual group were 46 Greek- and English-speaking bilingual children who were recruited from one Greek morning school (*N*=13) and two afternoon Greek schools (*N*=33) in London. Children in Study 1 had been recruited from the morning school and one of the Greek afternoon schools; the additional Greek afternoon school from which children were recruited for Study 2a was comparable in intake. The bilingual children's ages ranged from 7;08 to 10;08 (mean=7;09, *SD*=0;06). Children attending the Greek morning school followed the Greek national curriculum and children received instruction in Greek language art for eight hours per week and English literacy for ten hours per week. Most of the children spoke Greek at home. The afternoon school was for five hours per week, and approximately four hours were devoted to Greek literacy instruction. Children attending the afternoon schools attended mainstream English schools during the day. Pupils in both types of school were instructed in Greek literacy using an analytic and synthetic phonics approach, and in English literacy by a combination of whole word and phonics methods

The sample of bilingual children was divided into two groups on the basis of reading and spelling performance in Greek on the 60-word list. To form the strong and weak Greek groups the scores for reading and spelling accuracy were converted to z-scores and the groups were formed on the basis of a median split of the composite z-scores. There were 23 students in each group. The weak Greek group consisted of 14 girls and 9 boys, and the strong Greek group had 7 girls and 16 boys. As anticipated, the majority of the children from the morning school (12/13), where children received more hours of Greek language arts instruction than in the afternoon school, were in the strong Greek group. A language experience questionnaire was completed by the participants.

In the weak Greek group 70% of the participants reported that they mainly spoke English and 30% used both languages. In the strong Greek group 26% of the participants reported that they mainly spoke Greek, 22% mainly spoke English and 52% used both languages.

Independent t-tests were used to examine differences between the weak and strong Greek groups on the background variables. These revealed that the strong and weak Greek groups did not differ in terms of chronological age, or scores on the non-verbal reasoning test. Neither did they differ in English reading and spelling accuracy. There were significant group differences for Greek reading accuracy, $t(81)=10.78$, $p<.0001$, $r=.76$, and Greek spelling, $t(81)=5.79$, $p<.0001$, $r=.54$. The latter differences were to be expected, given the procedure used for grouping the bilingual participants.

Further analyses using one way ANOVAs revealed that results for chronological age, non-verbal reasoning, and reading and spelling accuracy did not differ significantly between the monolingual English and weak and strong Greek bilingual groups (see section below for description of the weak and strong Greek bilingual groups) (all $Fs<1$).

One-way ANOVAs comparing monolingual Greek speaking children and bilingual groups revealed that there were significant group effects for Greek reading and spelling accuracy, $F(2,78)=69.64$, $p=.000$, $\omega=0.6$ and $F(2,79)=64.83$, $p=.000$, $\omega=0.6$, respectively. Post-hoc analyses using the Games-Howell procedure revealed that the weak Greek bilingual group had significantly poorer reading scores than both the strong Greek, and monolingual Greek groups, $t(78)=9.9$, $p<.0001$, $r=.74$ and $t(78)=10.8$, $p<.0001$, $r=.77$ respectively. The scores of the strong Greek and monolingual groups did not differ significantly ($p>.05$). For the spelling scores, the weak Greek bilingual group had significantly poorer scores than the strong Greek and monolingual groups, $t(79)=5.7$, $p<.0001$, $r=.54$ and $t(79)=11.36$, $p<.0001$, $r=.78$, respectively. Finally, the spelling scores of the monolingual group were significantly better than those of the strong Greek group $t(79)=5.0$, $p<.0001$, $r=.5$.

Materials

The bilingual and monolingual participants were assessed on the tasks outlined below. All were administered by the researcher, who is bilingual in Greek and English.

Child-related variables

Scores on assessments of phonological awareness (PA) and visual memory were used to examine child-related variables in relation to spelling performance.

Phonological Awareness

Blending subtasks for Greek from the Athena Test (Paraskevopoulos et al., 1999) and for English from the CTOPP (Wagner et al., 1999) were used. A description of these is given in Study 1.

Visual short-term memory

Two subtests from the Athena Test (Paraskevopoulos et al., 1999) were used, Memory for Designs and Memory for Pictures. A description of the tasks is given in Study1.

Stimulus-related variables

The effect of the stimulus-related variables printed word frequency and least transparent phoneme-grapheme probability were examined in the item analyses. Descriptions of the variables are given in Study 1.

Procedure

The study began once Institute of Education, London, ethical approval had been obtained and letters of parental consent for children's participation were received. The testing of the bilingual participants took place in two different periods. Twenty eight participants were tested from February to May in 2009 and 18 participants were tested from February to May, in 2011. Monolingual children were tested between February and May 2011. Children were seen in a quiet room at their school. Children were asked to read the 60 words in the Masterson et al. list as accurately as possible. Children's responses were recorded for later verification. In a separate testing session (one month later) children were presented with the words for spelling to dictation. The stimuli for spelling to dictation, in the case of the bilinguals, were split into three sets of 40 items (both English and Greek words- total 120 items), with blocks of 20 Greek and 20 English words in each set, and two sets of 30 items for the monolingual controls. The sets were presented in three for the bilingual and two for the monolingual groups in separate sessions that lasted from 15 to 20 minutes each. Finally, the blending test, and visual memory and non-verbal reasoning tests were administered in further sessions lasting 15-25 minutes, in order to avoid participant fatigue.

Results

Following calculation of descriptive statistics, intra-language correlational analyses were conducted, using the Predictive Analytics SoftWare (PASW, version 18). Regression analyses were also conducted, first with the child-related and then the stimulus-related variables, looking at predictors of spelling performance. The final section of the Results provides the results of qualitative analysis of the children's spelling errors.

Child-related variables

Descriptive statistics are reported in Table 17 for the scores for the two monolingual groups and the strong and weak Greek bilingual groups on the visual memory and phonological awareness assessments. Reliability for all tasks was above .80.

Table 17: *Mean correct scores for the four groups of children on the phonological awareness and visual memory assessments in Study 2a (standard deviations are in parentheses)*

	Monolingual		Bilingual	
Task	English	Greek	Weak Greek	Strong Greek
PA English[α] (max=20)	14.12 (2.47)	-	14.35 (1.90)	14.91 (3.50)
PA Greek[b] (max=32)	-	25.39 (4.84)	18.22 (7.85)	21.39 (7.90)
VM pictures[c] (max=32)	18.55 (5.85)	16.11 (4.94)	19.09 (5.46)	16.65 (5.63)
VM designs[c] (max=32)	13.82 (5.31)	13.94 (5.09)	14.74 (5.88)	14.26 (5.11)

Note: [α]CTOPP (Wagner, et al., 1999), [b]from Athena Test (Paraskevopoulos et al., 1999). [c]Visual memory tasks, Athena Test (ibid.).

One-way ANOVAs were used to investigate whether there were significant differences among the two bilingual groups and the English monolingual group in PA and visual memory. In no case was there a significant effect (all $Fs<1$). The same analyses were carried out for the bilingual groups and the Greek monolingual group. There was a significant group effect for PA, $F(2,79)=8.27$, $p<.001$, $\omega=0.15$. Post-hoc analysis using the Games-Howell procedure showed that scores for the monolingual group were significantly higher than those of the weak Greek group, $t(79)=4$, $p<.0001$, $r=.41$, and the strong Greek group, $t(79)=2.17$, $p<.05$, $r=.23$. There were no other significant differences.

Interrelationships among variables

Prior to analyses, data were checked for positive or negative skew. Positive skew in the scores for English spelling was corrected by applying first logarithmic and then square route transformation. Inspection of the correlation coefficients showed no differences whether data were transformed or not. Consequently, transformation was not applied to the spelling scores. Table 18 and 19 present the partial correlations, controlling for age, between the measures for each group.

Table 18: *Partial correlations between spelling accuracy and scores on other assessments in Study 2a, the upper orthogonal represents correlations for the Greek monolinguals and the lower orthogonal represents correlations for the English monolinguals*

	Spell[α]	NVA[b]	Read Ac[c]	PA[d]	VMP[e]	VMD[f]
Spell	-	.25	.21	.38*	.23	.15
NVR	.52**	-	-.00	.50**	.02	.02
Read Acc.	.81****	.34	-	.12	-.08	.10
PA	.43*	.25	.46**	-	.05	-.16
VMP	.42*	.36*	.22	.16	-	.47**
VMD	.11	.49**	.17	.23	.17	-

Note: [a]Spelling in the 60-word list (Masterson et al., 2008), [b]Standardized Score, Matrix Analogies Test (Naglieri, 1985),[c]Reading Accuracy 60-word list, [d]Phonological ability, CTOPP [e]Visual memory for pictures, [f]Visual memory for designs, *$p<.05$, **$p<.01$, ***$p<.001$

Table 19: *Partial correlations between spelling in English and other measures in Study 2a, the upper orthogonal presents correlations for the strong Greek group and the lower for the weak Greek group (Time 1 assessment)*

	Spell[a]	NVA[b]	Read Ac[c]	PA[d]	VMP[e]	VMD[f]
Spell	-	.36	.81***	.83***	.49*	-.02
NVR	.74***	-	.26	.39	-.08	.01
Read Ac.	.78***	.72***	-	.82***	.32	.05
PA.	.19	.33	.44*	-	.27	.12
VMP	.12	-.04	.08	.07	-	.08
VMD	.59**	.45*	.35	-.18	.34	-

Note: [a]Spelling in the 60-word list (Masterson et al., 2008), [b]Standardized Score, Matrix Analogies Test (Naglieri, 1985),[c]Reading Accuracy 60-word list, [d]Phonological ability, CTOPP [e]Visual memory for pictures, [f]Visual memory for designs, *p<.05, **p<.01, ***p<.001

Monolingual English children's spelling scores were significantly associated with reading accuracy r=.81, p<.0001, non-verbal reasoning r=.52, p<.001, PA r=.43, p<.05, and visual memory for pictures r=.42, p<.01. For the monolingual Greek group spelling scores were associated with PA r=.38, p<.5. English spelling for the weak Greek bilingual group correlated significantly with reading accuracy r=.78, p<.001, non-verbal reasoning r=.74, p<.001 and visual memory for designs r=.59, p<.01, but not with PA. For the strong Greek bilingual group, significant correlations were observed between spelling and reading accuracy r=.81, p<.001, PA r=.83, p<.001 and visual memory for pictures r=.49, p<.05.

Results of regression analyses with child-related variables as predictors

Separate simultaneous multiple regression analyses were conducted for each group. The criterion variable consisted of correct spelling scores in the 60-word list. Predictor variables in each analysis were scores for PA and scores for visual memory for all four groups. Principal component analysis indicated that a single combined score (derived from the two different visual memory assessments, Memory for Pictures and Memory for Designs), could be used in the regression analyses as significant correlations were observed for scores on the two subtasks (range *r*=.27 to *r*=.49).

A summary of the analyses is provided in Table 20. The overall regression model was significant for each of the groups: monolingual English, $F(2,30)=6.4$, $p<.01$, monolingual Greek, $F(2,37)=6.8$, $p<.01$, strong Greek bilingual, $F(2,20)=25.9$, $p<.0001$, and weak Greek bilingual, $F(2,20)=3.7$, $p<.05$.

Table 20: *Results of regression analyses with spelling scores in English for the English monolingual and two bilingual groups, and in Greek for the Greek monolingual group in Study 2a*

	Monolingual								Bilingual							
	English				Greek				Weak Greek				Strong Greek			
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2	B	SE	β	R^2	B	SE	β	R^2
Visual memory	5.1	2.2	**.36***	.30	1.4	1.4	.15	.29	4.9	1.9	**.48***	.29	1.3	1.9	**0.1**	**.72**
Phonological awareness	1.9	0.9	**.33***		0.7	0.2	**.48****		1.2	1.0	.23		3.4	.53	**.81*****	

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, *$p<.05$,**$p<.01$, ***$p<.001$

Both PA and visual memory for pictures were significant predictors in the monolingual English group, PA explained 18% of variance and visual memory 20% of variance. PA was a significant predictor of Greek spelling for the monolingual Greek participants, explaining 26% of variance. For the strong Greek bilingual participants, PA was a significant predictor of English spelling and accounted for 72% of variance. For the weak Greek bilingual group visual memory for designs was a significant predictor, and accounted for 23% of variance.

It can be seen, then, that the spelling in English of the bilingual children with high levels of proficiency in Greek appears to be affected by PA, as in the case of monolingual Greek children, and in line with the notion that learning to read and spell in Greek leads to a reliance on phonologically based sublexical processes for spelling. The results for the bilingual children with lower levels of proficiency in Greek however, indicate that spelling performance is influenced by visual memory. This suggests greater reliance on visually-based lexical processing, and is in line with the results for the monolingual English children, for whom visual memory was also a significant predictor of spelling performance. Unlike the weak Greek bilingual group, the spelling of the monolingual English group was also significantly predicted by PA. This difference in pattern of results across the two groups may be due to lack of statistical power as a result of the smaller number of participants in the bilingual group compared to the monolingual English group (23 in the former vs. 33 in the latter).

Stimulus-related variables

Separate simultaneous multiple regression analyses were conducted for each group with the item data (number of correct responses per item in the 60-word list calculated across participants) as the criterion variable. Printed word frequency and least transparent phonographeme values (LTPG) were the predictor variables. Prior to the analyses the data were checked for normality. A logarithmic transformation improved the fit of printed word frequency; consequently, analyses reported are based on the log frequency values.

Results of regression analyses with stimulus-related variables as predictors

A summary of the results of the analyses is provided in Table 21. The overall regression model was significant for the monolingual English group, $F(2,57)=17.63$, $p<.0001$, the monolingual Greek group, $F(2,57)=8.08$, $p<.001$, the strong Greek bilingual group, $F(2,57)=13.28$, $p<.0001$, and the weak Greek bilingual group, $F(2,57)=15.20$, $p<.0001$.

Table 21: *Results of regression analyses with spelling accuracy (item data), for English in the case of the English monolingual and two bilingual groups and Greek for the Greek monolingual group as the criterion variable in Study 2a*

	Monolingual								Bilingual							
	English				Greek				Weak Greek				Strong Greek			
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2	B	SE	β	R^2	B	SE	β	R^2
Frequency	13.4	2.9	**.47*** **	.43	0.6	0.2	**.28***	.22	6.5	1.6	**.42*** **	.35	5.3	1.3	**.44*** **	**.32**
LTPG	860	252	**.35*** **		502	176	**.34** **		485	139	**.37*** **		308	111	**.31** **	

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, *p<.05, **p<.01, *** p<.001

Both printed word frequency and LTPG were significant predictors of spelling accuracy for all the groups. Specifically, the results revealed that for the monolingual English group, frequency explained 26% of variance and LTPG 16% of variance. For the monolingual Greek participants, LTPG explained 15% of variance and frequency 11% of variance. For the strong Greek bilingual participants, frequency accounted for 22% of variance and LTPG for 12% of variance. For the weak Greek bilingual group frequency accounted for 21% of variance and LTPG for 17% of variance. The finding that both frequency and LTPG predicted the spelling performance of the monolingual English group is in line with the results obtained by Spencer (2007) with English-speaking children, indicating the use of both lexical and sublexical processing. The monolingual Greek group showed evidence of use of both lexical and sublexical processing. Findings are in agreement with Study 1 and with previous studies in transparent orthographies which have also indicated that both lexical and sublexical procedures are used for reading and spelling, at least after the earliest stages of literacy acquisition have been surpassed (e.g., Loizidou et al., 2009, see also section 2.4.1. & 3.3.).

Qualitative Analysis

A qualitative analysis of the children's spelling errors in the 60-word list was conducted. Errors were divided, as in Study 1, into phonologically appropriate errors and non-phonologically appropriate errors. Percentages of each category of error were calculated for the groups separately.

The monolingual English children made an average of 67% phonologically appropriate errors, while monolingual Greek participants made an average of 94%. The strong Greek group made more phonologically appropriate errors (mean=55%) than the weak Greek group (mean=42%). The difference between the two groups was significant, $t(44) = 2.10$, $p < .05$, $r = .09$.

Interim Summary

The focus of the present study was to look for evidence of possible differences in the processes used for spelling in English by children with different levels of proficiency in reading and spelling in transparent Greek. Specifically, the aim was to investigate whether use of sublexical processes might be more apparent in children with strong Greek literacy skills, while visually-based whole word processes might be more apparent in the spelling of children with weak Greek literacy skills.

The weak and strong Greek groups did appear to differ in their reliance on processes for spelling in English. In analyses involving the child-related variables, spelling accuracy in the strong Greek group was significantly predicted by a measure of PA (blending), while for the weak Greek group, scores on the visual memory assessment significantly predicted spelling. The results for the monolinguals in this study were largely consistent with those of Study 1. Monolingual English children's spelling accuracy was predicted by visual memory scores as well as PA scores, which was found in Study 1 for the younger English monolingual participants. For monolingual Greek children, spelling was significantly predicted by both visual memory and PA in Study 1 but by PA only in Study 2, suggesting stronger influence of sublexical processes in spelling in this group. This cannot be due to differences in sample size or in level of reading and spelling, as these seem to be very comparable between the monolingual group in Study 2a and the one in Study 1. The result might be due to the use of a different PA measure (blending in Study 2a and combined blending and spoonerisms in Study 1), but generally results from Study 2a are in line with those of Study 1.

Study 2b reports data from the bilingual English- and Greek-speaking children in Study 2a that were collected one year later, in order to investigate whether there might be change in the predictors of English spelling over time. The mean age of the children in Study 2a was comparable to that of the younger groups in Study 1. The older (mean age nine years) monolingual Greek group in Study 1 showed a shift to greater influence of lexical processing in spelling with age (visual memory was more strongly associated with spelling at age nine (p=.01) than PA (p=.05)). It was possible that the strong Greek bilingual group in Study 2 would show more of an influence of lexical processing in their spelling in the one year follow-up study.

5.2. Study 2b: Time 2 assessment

The study aimed to see whether there was any evidence of developmental change in the spelling processes observed in the bilingual children who took part in Study 2a. It proved possible to re-test 28 out of the 46 bilingual participants one year after the original study, when the children were aged eight to ten years. Children were tested again on the same assessments in order to examine possible reciprocal relationships between the variables (Perfetti, Beck, Bell, & Hughes, 1987).

Method

Participants

Participants were 15 of the original 23 children (ten girls, five boys) in the weak Greek literacy group and 13 of 23 (four girls, nine boys) in the strong Greek group. Data were collected exactly one year after the first assessment when the mean age of the children was 9;00, *SD*=0;06 (range = 8;02-10;09). The same analyses as those conducted at Time 1 were carried out in order to examine the child- and stimulus-related variables that may be influencing spelling. Table 22 gives a summary of the participant characteristics for the present sample at both testing times. Independent t-tests were used to examine differences between the groups on the background variables. These revealed that the groups did not differ in terms of chronological age, or non-verbal ability. Neither did they differ in accuracy in reading or spelling in English on the Masterson et al. 60-word list. There were significant group differences for Greek reading accuracy, $t(26)=4.54$, $p<.0001$, $r=.44$ and Greek spelling, $t(26)=6.13$, $p<.0001$, $r=.59$. These differences were to be expected, given the original procedure that had been used for selecting the children. Significant differences are marked in the table with asterisks.

Table 22: *Summary of participant characteristics of the strong and weak Greek bilingual groups in Study 2b (standard deviations are in parentheses)*

	Weak Greek (N:15)	Strong Greek (N:13)
Age (in years)	9;01	8;09
	(0;07)	(0;04)
Non-verbal reasoning$^{\alpha}$ (standardised scores)	103	105
	(35)	(23)
English reading$^{\beta}$ (% correct)	93	95
	(5.7)	(4.2)
English spelling$^{\beta}$(% correct)	70	80
	(15)	(12)
Greek reading$^{\beta}$ (% correct)	69****	98
	(22)	(4.2)
Greek spelling$^{\beta}$ (% correct)	23****	54
	(10)	(16)

Note: $^{\alpha}$Standardized Score, Matrix Analogies Test (Naglieri, 1985), 60-word list (Masterson et al., 2008) $^{****}p$<.0001

Results

Correlational analyses were conducted, using the Predictive Analytics SoftWare (PASW, version 18), concurrently and longitudinally, first for the child- and then for the stimulus-related variables. Simultaneous regression analyses were also performed, looking concurrently and longitudinally at predictors of English spelling. The final section of the Results provides the outcome of a qualitative analysis of the spelling errors.

Child-related variables

Descriptive statistics are reported in Table 23 for the weak and strong Greek groups, in terms of the child-related variables at the second time of testing. There were no significant differences between the groups in PA or visual memory, apart from visual memory for pictures where there was a marginal difference, $t(26)=2.24$, $p=.05$, in favour of the weak Greek group. Significant differences are marked in the table with asterisks.

Table 23: *Mean correct scores for the weak and strong Greek bilingual groups on the PA and visual memory assessments in Study 2b (standard deviations are in parentheses)*

Task	Weak Greek	Strong Greek
PA English[α] (max=20)	13.07	14.85
	(3.28)	(3.33)
PA Greek[b] (max=32)	18.27	24.54
	(10.56)	(5.42)
Visual memory pictures[c] (max=32)	24.80*	20.58
	(4.34)	(5.68)
Visual memory designs[c]max=32)	21.07	19.15
	(5.04)	(4.31)

Note: [α]CTOPP (Wagner et al., 1999), [b]from Athena Test (Paraskevopoulos et al., 1999), [c]Visual Memory, Athena Test (ibid.). $^{*}p<.05$

Interrelationships among variables

Prior to analyses data were checked for positive or negative skew. Positive skew on the scores for English spelling was corrected by applying both logarithmic and square root transformation. A comparison of the analyses revealed no differences if data were or were not transformed. Consequently analyses are reported without transformation of spelling scores. Correlations between the measures were examined for each group and results are presented in Table 24. Partial correlations controlling for age were not conducted due to the small sample size (N=15 for the weak Greek literacy group and N=13 for the strong Greek literacy group.

Table 24: *Correlations between spelling in English and other measures at Time 2 in Study 2b, the upper orthogonal presents correlations for the strong Greek group and the lower for the weak Greek group*

	Spell[α]	Age[b]	NVR[c]	Read Ac[d]	PA[e]	VMP[f]	VMD[g]
Spell	-	.35	.29	.69**	.78**	.11	.36
Age	.32	-	.02	.41	.34	.35	.33
NVR	.81***	.22	-	.37	.20	-.11	-.06
Read Ac.	.61*	.09	.58*	-	.89***	.46	.15
PA.	-.25	.18	-.13	-.23	-	.40	.32
VMP	.63*	.23	.61*	.21	-.01	-	.25
VMD	.63*	.25	.82***	.27	-.07	.51*	-

Note: [a]Spelling in the 60-word list (Masterson et al., 2008), [b]Age in months, [c]Standardized Score, Matrix Analogies Test (Naglieri, 1985),[d]Reading Accuracy 60-word list, [e]Phonological ability, CTOPP [f]Visual memory for pictures, [g]Visual memory for designs, *p<.05, **p<.01, ***p<.001

At both times of assessment, reading and spelling accuracy were significantly correlated. Reading accuracy was close to ceiling, and consequently we will not focus on this measure further. English spelling for the weak Greek group correlated significantly with non-verbal ability and visual memory. For the strong Greek group, a significant correlation was observed between PA and spelling.

Correlations across groups and time points

Next correlations across groups and times of assessment will be presented in order to appreciate the consistency of trends. As the groups were comparable in age it would be interesting to see if there are differences in the correlations. Correlations reported for Studies 1 and 2a are controlling for age. This was not possible for Study 2b due to the sample size (see Table 25).

Table 25: *Correlations across groups and times of assessment between single word spelling performance (English for the monolingual English and bilingual groups and Greek for the monolingual Greek groups) and critical variables*

	Monolingual English			*Monolingual Greek*			*Bilingual*					
Group	Young Study 1	Young Study 2a	Old Study 1	Young Study 1	Young Study 2a	Old Study 1	Young Study 1	Young WG Study 2a	Young SG Study 2a	Old Study 1	Old WG Study 2b	Old SG Study 2b
Non-verbal reasoning	**.51****	**.52****	**.49****	.33	.25	.42	.03	**.74*****	.36	.38	**.81*****	.29
Blending	**.43***	**.43***	.36	**.53*****	**.38***	.35	**.56****	.19	**.83*****	.21	-.25	**.78****
Visual memory for Pictures	**.39***	**.42***	**.62*****	**.49****	.23	.48	.19	.12	**.49***	.18	**.63***	.11
Visual memory for Designs	.23	.11	.14	.32	.15	**.70****	.24	**.59****	-.02	.06	**.63***	.36

Note:**p*<.05, ***p*<.01, ****p*<.001

Correlations for the young monolingual English speaking groups indicate strong associations between non-verbal ability, blending and visual memory for pictures and spelling skill. For the older children blending is not significantly associated with children's spelling performance and visual memory is more strongly associated in comparison with the younger children. The association between spelling and scores for visual memory for pictures was higher for the older monolingual English speaking children than the association between spelling and visual memory for the younger groups (z=-1.2 comparison between older and younger Study 1 and z=-1.08 comparison between older and younger Study 2a), however the difference was not significant.

For the Greek participants a main difference detected is that visual memory for pictures is not significantly associated with the young monolingual children's spelling assessed for Study 2a. This cannot be attributed to age differences or differences in performance in visual memory for pictures (16.11, *SD*=4.9 & 16.3, *SD*=5.9 for each group). For the older children, blending was not significant. For these children visual memory for designs was significantly associated with single word spelling skill.

For the bilingual younger children and the strong Greek bilingual group at both times of assessment PA was associated with spelling skill. For the children with weak Greek literacy skills only scores in visual memory tasks and non-verbal ability were significantly associated with single word spelling.

Regression Analyses

Simultaneous multiple regression analyses were conducted with the English spelling scores for the two groups as the criterion variable. Predictor variables were PA and visual memory combined score. The results were similar to those observed in the original analyses. The overall regression model was significant for both groups (for the strong Greek group, $F(2, 10)=9.54$, $p<.01$, and for the weak Greek group, $F(2,12)=8.1$, $p<.01$). A summary is provided in Table 26.

Table 26: *Results of regression analyses with child-related variables and English spelling accuracy as the criterion variable in Study 2b*

	Weak Greek				Strong Greek			
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2
Visual Memory	6.3	1.6	**.71****	.57	-.51	1.5	-.07	.61
P A	-.58	.51	-.21		1.7	.47	**.81****	

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardised beta values, R^2=the proportion of data explained by the model, *p<.05, **p<.01

PA accounted for 61% of variance for the strong Greek group and visual memory accounted for 53% of variance for the weak Greek group.

Interrelationships among variables longitudinally

Correlations were conducted between scores at the original time of testing (Time 1, T1) and at the Time 2 assessment one year later (T2) in order to investigate associations between the scores at the two time points. Findings of the correlations are presented in tables 27 and 28.

Table 27: *Correlations between spelling in English and other measures at Time 1 and Time 2 (Study 2b) for the weak Greek literacy bilingual group*

	Spell[α]*T2*	Age[b]*T2*	NVR[c]*T2*	Read Ac[d]*T2*	PA[e]*T2*	VM[f]*T2*
Spell*T1*	.93***	.42	.72**	.54*	.-06	.66**
Age*T1*	.32	1***	.22	.09	.18	.28
NVR*T1*	.71**	.54*	.74**	.62*	.13	.46
Read Ac.*T1*	.71**	.38	.63*	.66**	.21	.241
PA.*T1*	-.05	.28	-.05	.08	.76***	.06
VM*T1*	.84***	.11	.66**	.45	-.04	.75***

Note: [a]Spelling in the 60-word list (Masterson et al., 2008), [b]Age in months, [c]Standardized Score, Matrix Analogies Test (Naglieri, 1985), [d]Reading Accuracy 60-word list, [e]Phonological ability, CTOPP [f]Visual memory combined score, *p<.05, **p<.01, ***p<.001

Table 28: *Correlations between spelling in English and other measures at Time 1 and Time 2 (Study 2b) for the strong Greek literacy bilingual group*

	Spell[a]*T2*	Age[b]*T2*	NVR[c]*T2*	Read Ac[d]*T2*	PA[e]*T2*	VM[f]*T2*
Spell*T1*	.85***	.22	.24	.75**	.92***	.49
Age*T1*	.35	1***	.22	.41	.33	.44
NVR*T1*	-.01	-.02	.-.09	-.01	.15	.16
Read Ac.*T1*	.72**	.45	.13	.61**	.76**	.72**
PA.*T1*	.81***	.38	.28	.69**	.76***	.26
VM*T1*	.49	.17	.05	.53	.40	.55

Note: [a]Spelling in the 60-word list (Masterson et al., 2008), [b]Age in months, [c]Standardized Score, Matrix Analogies Test (Naglieri, 1985),[d]Reading Accuracy 60-word list, [e]Phonological ability, CTOPP [f]Visual memory combined score , ***p*<.01, ****p*<.001

For the weak Greek group a high correlation was obtained between T1 spelling and T2 spelling. Visual memory at T1 also significantly correlated with spelling at T2, *r*=.84, *p*<.0001. Significant associations were also observed between nonverbal ability and reading accuracy at T1 with spelling at T2.

The same analyses were carried out for the strong Greek group. T1 spelling and PA, *r*=.81, *p*<.0001, were the most significant associations with T2 spelling performance. T1 reading accuracy also correlated with T2 spelling.

Regression Analyses

In order to further investigate the relations between the variables longitudinally, simultaneous multiple regression analyses were conducted. For English spelling at T2, predictor variables were phonological ability and visual memory combined score at T1. A similar result was obtained to that observed in the previous analyses. The overall regression model was significant for both groups (for the strong Greek group *F*(2, 10)=10.6, *p*<.01, and for the weak Greek group, *F*(2,12) =14.8, *p*<.001). The results are provided in Table 29.

Table 29: *Results of regression analyses with child-related variables at Time 1 and English spelling accuracy at Time 2 as the criterion variable in Study 2b*

	Weak Greek				Strong Greek			
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2
Visual Memory	7.4	1.4	**.84*******	.71	1.1	1.4	.15	.68
PA	.35	.86	.06		2.1	.57	**.75****	

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, ** *p*<.01, **** *p*<.0001

PA at T1 accounted for 66% of variance in spelling at T2 for the strong Greek group and visual memory at T1 accounted for 71% of variance at T2 for the weak Greek group.

Path Analysis

Based on the correlation and regression outcomes, path analysis was conducted with the exogenous variables phonological ability and visual memory at T1 and two endogenous variables spelling at T1 and at T2 for each group. In Figure 6 the significant paths and beta weights are presented.

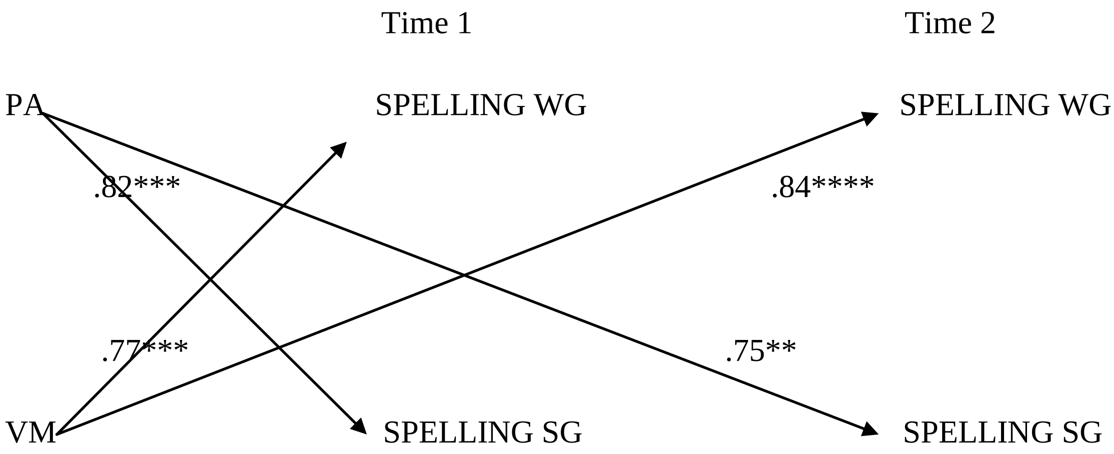


Figure 6: *Path analysis showing the associations between phonological awareness and visual memory at Time 1 and spelling at each time point for the weak and strong Greek bilingual groups in Study 2b*

The path analysis indicates that phonological ability was a concurrent and longitudinal predictor of spelling for the strong Greek group, and for the weak Greek group visual memory was a concurrent and longitudinal predictor of spelling.

Stimulus-related variables

As for examination of the concurrent associations, total number correct per item in the 60 word list was calculated, and regression analyses were conducted with item characteristics in order to examine relations among stimulus-based variables and spelling performance. As noted in the analysis of the concurrent associations, logarithmic transformation improved the fit of frequency; consequently, analyses reported are based on the log frequency values.

Regression analyses

Simultaneous multiple regression analyses were conducted to examine the predictors of T2 spelling for the weak and strong Greek groups. Item totals for spelling in English were used as the criterion variable. Frequency and LTPG were predictor variables. A summary of the result is provided in Table 30. The overall regression models were both significant (p<.001).

Table 30: *Results of regression analyses with stimulus-related variables and English spelling scores at Time 2 as the criterion variable in Study 2b*

	Weak Greek				Strong Greek			
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2
Frequency	5.6	1.6	**.39*** **	.24	5.3	1.2	**.45*** **	.29
LTPG	300	139	**.25***		178	107	**.26***	

Note: [a]Unstandardized beta values [b]Standard error of the coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, *p<.05, *** p<.001

Frequency and LTPG were significant predictors of spelling accuracy for the weak and the strong Greek literacy group.

Qualitative analysis

The children's spelling errors at Time 2 in the 60-word list were again classified as phonologically appropriate or non-phonologically appropriate in order to compare the outcome with that obtained at Time 1. The mean rate of phonologically appropriate errors was 69% (*SD*=19.8) for the strong Greek group and 50% (*SD*=14.1) for the weak Greek group. The difference between the groups in percentage of phonologically appropriate errors was significant, $t(26) = 2.86$, $p<.01$.

Interim Summary

From a range of variables investigated in Study 1, the research in Study 2 focused on variables that have been associated with lexical and sublexical processes in the research literature. The child-related variables selected were phonological ability and visual memory, and the stimulus-related variables were LTPG and printed word frequency. The results of Study 1 revealed that for monolingual Greek children, phonological processes seem to have a stronger influence than lexically-related variables. For the younger and older monolingual Greek children, both PA and visual memory were significant predictors. This was the same pattern as observed for the English younger group. For the older English monolingual group in Study 1 only visual memory was a significant predictor. The analyses of stimulus-related variables indicated that for the English monolingual children, while frequency and LTPG were both significant for the younger children, only frequency was a significant predictor for the older children. This was not the case for the Greek children since LTPG continued to be a significant predictor, along with frequency, for the older children. This indicates that phonologically-based processes continue to be more influential for the Greek monolingual children than is the case for the English monolingual children.

The results of Study 2 revealed that for pupils with strong Greek, PA predicted spelling in English, whereas for pupils with weak Greek visual memory was influential. These findings were confirmed one year later. Spelling performance of the strong Greek group was in line with that of monolingual Greek speaking children in Study 2 and the pattern of findings for the weak Greek group was similar to that of the monolingual English speaking children. The results suggest transfer of processing from one language to another in biliterates, as the previous literature suggests (Mumtaz & Humphreys, 2001, 2002; Xuereb, 2009; De Sousa et al., 2010, see sections 2.5.1. for a review).

In Study 3, reported next, letter report is investigated as a lexically-associated variable. The design used in Study 1 was employed again to investigate the influence of lexical and sublexical processes in the spelling of monolingual and bilingual Greek and English children.

6. Study 3: Association of single word spelling with letter report tasks in monolingual and bilingual Greek- and English-speaking children[4]

Introduction

In Study 3 monolingual and bilingual Greek- and English-speaking children were assessed in letter report tasks, phonological ability, RAN and visual memory as it was considered important to investigate the association of simultaneous multi-character processing and spelling. Studies of TD children and of children with dyslexia\dysgraphia have looked at the role of multi-character processing ability mainly in reading. As it will be presented next multi-character processing was included as a child-related variable in order to investigate its role as a lexically related variable in association with spelling performance.

Simultaneous multi-character processing ability

Multi-character processing ability was explained by the *multiple-trace memory model* (ACV98) of reading put forward by Ans, Carbonnel, and Valdois (1998). According to this, skilled reading involves global and serial, analytic processing. Poor performance in the letter report task was interpreted as reflecting a reduction in visual attention span. It was suggested that this would affect global processing and would lead to especial difficulty reading irregular words (e.g., *yacht, mortgage*) since acquisition of orthographic recognition units for irregular words is particularly dependent on simultaneous processing of all the letters in a word. In addition, reading latencies in general would be longer, since the deficit causes a reliance on analytic processes. This reduction in the visual attention span window, according to the researchers, could be characteristic of developmental surface dyslexia. Affected participants would produce mainly regularization errors in reading as analytic processing would be unimpaired. Alternatively, a phonological deficit would affect analytic processing, and consequently non-word reading, leading to developmental phonological dyslexia[5].

[4] Part of the study was presented at the 13th European Congress of Psychology, Stockholm, 2013

[5] The main difference between the ACV97 model and the DRC model is that processing is not in parallel in the two routes in the former; the global procedure precedes the analytic procedure. In case a failure occurs in word recognition of the global procedure the analytic procedure gains control. The two processes are also the main difference between the aforementioned model and single route connectionist models (e.g. Plaut, 2005).

The significance of simultaneous multi-character processing skill was demonstrated by Bosse, Tainturier, and Valdois (2007) who assessed a cohort of 68 dyslexic children (mean age: 11;06) and 55 controls (mean age: 11;06) in France and 29 dyslexic (mean age: 10;05) and 26 controls (mean age: 10;06) in England. They employed a global and partial letter report task. In the former, all the letters in the array are reported, while in the latter a bar probe is presented after the array to request report of just one letter (for a description of the tasks see bellow). Some of the dyslexics showed a selective letter report impairment and some a selective phonological deficit. In this study with dyslexic participants and in Bosse and Valdois (2009) with typically developing readers (*N*=417), the researchers demonstrated that global and partial letter report tasks were associated with reading performance independently of PA even after controlling for age and IQ, expressive vocabulary and single letter recognition ability. Particularly in the Bosse and Valdois cross-sectional study with first, third and fifth graders the researchers provided evidence that letter report was a predictor of irregular word reading across grades, independent of PA. They also found that the effect of letter report on non-word and regular word reading declined gradually from first to fifth grade. Bosse and Valdois concluded that the findings demonstrated the relation between simultaneous multi-character processing skill and orthographic learning in agreement with predictions of the *multiple-trace memory model*. In another group study with adolescents who were good readers but poor spellers, Lowe (2009) reported that the majority (56%) showed a selective letter report deficit. The remainder of the sample exhibited a phonological deficit, or else both a phonological and a letter report deficit.

In subsequent work by Dubois et al. (2010) the researchers presented evidence from two case studies with developmental dyslexia. The researchers suggested that a range of deficits could be responsible for deficient performance in letter report tasks and put forward as potential candidates a) the slow uptake of letter information, b) a limitation of the number of elements that can be extracted from a briefly presented array and stored in visual memory, and c) an imbalance of spatial attentional distribution. These explanations were according to the theory of visual attention of Bundesen (1990). Dubois et al. found that participants had reduced visual processing speed and that one of them had a visual short-term memory capacity limitation. They also found that none of them showed evidence of imbalance in attentional distribution. Consequently, it seems that reduced visual attention span window could relate to slow visual processing speed.

Hawelka and Wimmer (2008) claimed that the deficit in multi-character processing is not visual but phonological, in agreement with the core phonological deficit. They carried out a study using a task consisted of two-, four, and six-item digit arrays and the participant had to name the cued digit. The presentation time for the array varied from 250ms to 1100ms depending on the accuracy of the participant. They found that the eighteen dyslexic participants performed as accurately as the control children. However, the task used by the researchers was not a time constrained one so Hawelka and Wimmer argued subsequently that it might not actually tap visual attention span.

Like Hawelka and Wimmer, Ziegler et al. (2010b) investigated the possibility that poor performance in letter report tasks was associated specifically with verbal stimuli. In their study they used alphanumeric and non-verbal stimuli (for example, /, }, <,) in a forced choice visual span task. The results revealed that the performance of dyslexics did not differ from that of control children with the non-verbal stimuli; however, there was a significant group difference with alphanumeric stimuli. On this basis the researchers argued that the letter report task that has been used to asses visual attention span by Bosse et al. involves a phonological component, and they concluded that dyslexics exhibited a visual-to-phonology mapping deficit. Specifically, Ziegler et al. argued that digits and letters, but not other symbols, produced impaired performance in dyslexia, as dyslexics have difficulties in accessing phonological representations in long term memory. The researchers continue that a naming deficit could be an explanation for difficulty in reporting the letter arrays in the letter report tasks, and not the reduction in the visual attention window per se.

Valdois, Lassus-Sagosse, and Lobier (2012) conducted two experiments in order to evaluate the explanations put forward by Ziegler et al. (2010b). In the first experiment they used tasks involving naming of arrays of letters, digits, and colour patches. The latter stimuli were considered to be of low familiarity and as a consequence more difficult to name, as it is not usual for children to name arrays of colour patches. They found that for colour patches, report performance of both dyslexic and non-dyslexic children dropped significantly, indicating that visual processing of unfamiliar stimuli has a detrimental effect on performance of both groups. They also found that the dyslexic children performed worse than the non-dyslexic children for letter and digit report but not for colour report. Valdois et al. argued that since all three tasks (letter report, digit report and colour report) involve nameable stimuli then if the visual-to-phonology mapping deficit explanation of poor performance in multi-character processing tasks was correct dyslexics should have been impaired in all three tasks. In their second experiment a different group of dyslexic children and chronological age matched controls performed report tasks with letters with concurrent articulation and without. In line with predictions, the performance of the dyslexic group was worse than that of the control group, but critically, this was independent of concurrent articulation, indicating that performance in the letter report task is not reliant on this particular component of phonological processing.

Lobier, Zoubrinetzky, and Valdois (2011) also challenged the notion that the performance in the letter report task is related to phonological ability by employing a verbal and a non-verbal visual categorization task. They found that performance in the letter report task correlated with performance in both verbal and non-verbal categorization tasks, contrary to predictions from the visual-to-phonology code mapping hypothesis. Similarly, with these findings, Pammer et al. (2005, 2004) used a task with nonverbal material tapping simultaneous multi-character processing ability. The task employed arrays of five non-nameable letter-like shapes (containing a similar number of line elements to letters and related spatial frequency and contrast) and the participants had to choose among two alternative arrays the one that corresponded to the presented array. Pammer et al. found that performance of both children and adults was worse, not only for dyslexic participants but also for controls. The researchers reported that performance in their symbols task predicted lexical decision task scores independently from scores in measures of phonological memory, fixation speed and speed of processing. The findings argue against a phonological explanation of letter report performance.

Impaired letter report performance has been described in case studies and has been related to lexical processing deficits. Single case studies of French-speaking developmental dyslexics with impaired letter report were presented by Valdois et al. (1995) and Valdois (1996). For example, Valdois et al. (1995) reported a case study of a French 10-year-old dyslexic girl, Olivia. The authors argued that her deficit could not be explained by developmental stage theories as these do not differentiate between central and peripheral processes in reading. Olivia had slow reading speed and she appeared to make many visual confusion errors. The researchers attributed the difficulty to malfunction of peripheral processes. Valdois et al. argue that a reduced visual attention span could explain the word length effects in non-word reading that they observed in Olivia's reading, her slow reading speed, and the visual confusion errors.

They suggest that a reduced visual attention span restricts the ability to process words as wholes and leads to only partial processing of letters outside the window of visual attention span. Support for the association of impaired letter report and developmental surface dyslexia was also provided by two contrasting studies of phonological and surface dyslexia. Specifically, Valdois et al., (2003) reported the case of Nicholas, a 13 year old boy with impaired letter report. Nicholas had the characteristics of surface dyslexia/dysgraphia. They also reported Laurent, a boy with phonological dyslexia, who did not exhibit a deficit in letter report.

Similarly, Dubois et al. (2007) reported a case study of a 13 year-old French boy who had surface dyslexia in the absence of a phonological deficit. The researchers investigated his letter report performance according to letter position in the array. The optimal viewing position has been located slightly left from the centre of the word and performance produces a U-shape function (plotting letter position in a five-and seven-letter word naming task with typical readers). Researchers have reported this robust effect in a variety of tasks, e.g., naming, lexical decision, and probability to refixate (for a discussion, see Dubois et al.). MT's word report performance was affected by the number of letters in a word and when his performance was plotted according to letter position he produced in contrast to typical readers an inverted V-shape.

A letter report deficit has also been reported in a case study of Martial, a nine-year-old boy who had mixed dyslexia (poor reading of irregular words and nonwords) and surface dysgraphia (Valdois et al., 2011). Valdois et al. tested Martial with global and partial letter report tasks. He was found to have impaired global report but intact partial report performance. However, when Martial's performance in partial report was plotted according to letter position it was found to be atypical. Finally, Peyrin et al. (2013) also reported a relation between poor multi-letter processing and surface dyslexia.

Interim summary

Findings regarding the interpretation of the letter report deficit have caused controversy among the researchers. Although research has investigated letter report as an alternative deficit to PA in mono-scriptal participants' reading performance, there is no reported evidence with bi-scriptal English and Greek-speaking participants or mono-scriptal Greek- speaking children's spelling performance or with multilingual with reading and spelling difficulties. The current thesis aimed to address this in relation to bilingual and monolingual Greek- and English-speaking children' s spelling skill. As noted above, research evidence from typically developing children and those with literacy disorders (cf. Bosse & Valdois, 2009; Bosse et al., 2007) has suggested that simultaneous multi-character processing may be a component underpinning orthographic learning, independent from PA.

The present study extends the work on simultaneous multi-character processing to spelling since it has previously only been carried out in relation to reading. It also involves a bilingual population, and investigates letter report performance in Greek, a more transparent orthography than English. As noted previously, research has shown that PA is a core component for learning to spell in English, at least at the early stages of acquisition (Caravolas et al., 2001). Consequently, the study had two aims. The first was to provide further confirmatory evidence that simultaneous multi-character processing ability dissociates from phonological ability, and, as claimed by Bosse and Valdois (2009), is a lexically-related measure. The second was to investigate whether letter report would be a better lexically-related variable than visual memory. Children were also assessed in RAN for pictures, as Stainthorp et al. (2010) note that although a multi-character processing deficit has been investigated as an independent source of dyslexia, its relationship with rapid naming has not been explored. Consequently, for both multi-character processing and RAN an underlying visual processing deficit might be associated with reading difficulties. Therefore, it was considered important to investigate this relationship. Both correlation and regression analyses were conducted.

Method

The present study aimed to investigate how letter report, RAN and PA were associated with English spelling performance of monolingual and bilingual Greek- and English-speaking children and with Greek spelling performance of monolingual Greek-speaking children.

Participants

Monolingual English group

Monolingual English speaking children (*N*=34; 17 were girls) were recruited from three schools in North London, UK. The children's mean age was 8;06 years (*SD*=0;08, range=7;00-10;03). As for the monolingual group in Study 1, literacy instruction in the schools involved a combined whole word and phonics-based approach. All children reported that they were monolingual based on a language experience questionnaire. A summary of the participant characteristics for children in this group and the other groups is given in Table 31.

Monolingual Greek

Monolingual Greek speaking children (*N*=30; 11 were girls) were also recruited. Children did not differ from the monolingual English children in age and non-verbal ability. The children's mean age was 8;08 years (*SD*=0;05, range=7;05-9;09). Children were recruited from a single morning school in Chania, Greece. Literacy instruction in this school involved a phonics based approach. All children reported that they were monolinguals based on a language experience questionnaire completed with the help of the author.

Bilingual group

Participants in the bilingual group were 31 Greek- and English-speaking bilingual children (17 girls) who were recruited from a morning and two afternoon Greek schools in London, UK. Their mean age was 8;06 (*SD*=0;06, range=7;01- 9;08). A description of the educational experience of the children is given in Study 1. A language experience questionnaire was completed by participants with the author's help, 45% of children reported that they mainly spoke English at home and 42% used both languages and 13% reported that they used Greek at home.

Independent t-tests were used to look for differences in background measures across the groups. As before, significant differences are marked in the table with asterisks. The bilingual children did not differ significantly in any of the background measures from the monolingual English speaking children. For the Greek monolingual children and the bilingual children, results indicated that monolingual children did not differ significantly from the bilingual children in age and non-verbal ability, reading accuracy in the 60-word list, or in the list from Loizidou et al. However, the two groups differed significantly in spelling accuracy for the 60-word list, $t(59)=6.6$, $p<.0001$, $r=.65$ and the Mouzaki et al. test, $t(50.3)=6.4$, $p<.0001$, $r=.67$, with monolinguals outperforming bilinguals. As in the previous studies this result can be explained by the fact that the bilingual children were learning Greek as a second language in the UK.

Finally, a significant difference was also detected for nonword reading, with bilinguals outperforming monolinguals, $t(52)=2.5$, $p<.05$, $r=.32$.

Table 31: *Summary of age, non-verbal reasoning and scores for spelling and reading for the bilingual and monolingual participants in Study 3 (standard deviations are in parentheses)*

English measures		
	Monolingual (*N*:34)	Bilingual (*N*:31)
Age (in years)	8;06 (0;08)	8;06 (0;06)
Non-verbal reasoning[α] (standard score)	109 (17)	110 (16)
Spelling accuracy[β] (standard score)	109 (19)	106 (20)
Spelling accuracy[c] (% correct)	73 (16)	68 (18)
Reading accuracy[c] (% correct)	93 (7.3)	92 (6.3)
Irregular Reading[d] (% correct)	80 (13)	77 (16)
Regular Reading[d] (% correct)	87 (12)	83 (17)
Non-word Reading[d] (% correct)	77 (18)	77 (20)
Greek measures		
	Monolingual (*N*:30)	
Age (in years)	8;08 (0;05)	8;06 (0;06)
Non-verbal reasoning[α] (standard score)	104 (16)	110 (16)
Spelling[e] (standard score)	110*** (34)	81 (24)
Spelling[f] (% correct)	72*** (15)	45 (17)
Reading Accuracy[f] (% correct)	93 (7.8)	88.3 (19)
Reading Accuracy[g] (% correct)	90 (11)	86 (19)
Non-word Reading[g] (% correct)	70* (24)	85 (22)

Note: [α]Naglieri (1985), [β]WIAT-II, Teacher's edition, spelling subtest (Wechsler, 2006), [c] English Spelling and reading accuracy; 60-word list (Masterson et al., 2008), [d]DTWRP (Forum for Research in Language and Literacy, 2012), [e]Mouzaki et al. (2007), [f] 60-word list spelling and reading translated in Greek (ibid.), [g]list from Loizidou et al. (2009), * $p<.05$, *** $p<.001$, p values refer to comparisons between monolinguals and bilinguals

Materials

Children were assessed on PA using a spoonerisms task from the Phonological Assessment Battery (Frederickson et al., 1997), in RAN for pictures from the Phonological Assessment Battery (Frederickson et al., 1997) and in visual memory for pictures and designs from the Athena Test (Paraskevopoulos et al., 1999). These tasks had been used in Study 1. Additionally, the letter report task developed by Bosse et al. (2007) to assess simultaneous multi-character processing 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.

Letter strings appeared in uppercase (Consolas 14) in the center of a computer screen for 200ms which match with the mean duration of fixation in reading. To programme the task for presentation on the computer the DMDX software developed by Forster and Forster (2003) was used. The letters were presented on 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 to avoid grapheme complexity and orthographic knowledge, 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 12,309). This could result in more errors in the Greek version of the task compared with the English version (although this does not seem to have been the case – see Results in Table 32). Moreover, as 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.

Bilingual children were first tested in the English version and one week later in the Greek version. For the global report task, participants were asked to name as many letters as they could identify. Number of letters correctly reported and number of total arrays correctly reported were recorded (irrespective of whether letters were reported in the correct order or not).

Procedure

Testing began as soon as ethical approval was obtained from the Institute of Education, University of London Ethics Committee and as soon as letters of informed consent from parents and school authorities were returned. Children were seen in their school individually or in small groups for tests such as spelling. Data collection lasted from 2010 to 2012 and different children were assessed every year between the months February to May. Assessments lasted approximately 2 hours for the monolingual children and 4 hours for the bilingual ones. Monolingual children were seen for three sessions and bilingual children six sessions in order to avoid effects of fatigue. For the bilingual children the same task in Greek and English never co-occurred in the same testing session, and test administration was counterbalanced for language.

Results

For each group initially correlation analyses controlling for age and then multiple regression analyses, using the predictive analytic software PASW 20, were conducted. The aim was to examine the association of spelling for the monolingual and bilingual children with the lexical and sublexical related variables identified, including the letter report tasks. Prior to these analyses, descriptive statistics are given in Table 32. Data were checked for normality and variability. Spelling accuracy in the 60-word list was non-normal; therefore a logarithmic transformation was applied to improve the fit. However, it did not significantly change the associations, thus no transformations were applied. Prior to examining the associations, as in the previous studies, independent t-tests were used to look for differences between the groups on the critical variables. Significant differences are marked in the table of results with asterisks.

Results revealed no significant differences in scores for PA, RAN, visual memory for designs or letter report arrays or letters correct for the bilingual children and monolingual English children. However, there were significant differences between the two groups in partial report, $t(39)=2.1$, $p<.05$, $r=.32$, with the bilingual children outperforming the monolingual children, and in visual memory for pictures, $t(63)=2.8$, $p<.01$, $r=.33$, with the monolingual outperforming the bilingual children.

The same analyses were conducted for the scores of the monolingual Greek children and bilingual children. No significant differences were found for PA, for partial report and for the visual memory tasks. Significant differences were found for letter report arrays correct, $t(55)=2.3$, $p<.05$, $r=.30$, and letters correct, $t(55)=3.1$, $p<.01$, $r=.39$, and for RAN, $t(49)=4.8$, $p<.0001$, $r=.57$.

Table 32: *Summary of scores for measures of PA, RAN and global and partial letter report for the bilingual and monolingual participants in Study 3 (standard deviations are in parentheses)*

English measures		
	Monolinguals (N=34)	Bilinguals (N=31)
Spoonerisms[α] (max 20)	16 (3.9)	15 (3.5)
RAN[b] (secs)	50 (12)	55 (9.4)
Global report arrays correct[c] (max=20)	5 (4.9)	6 (5.2)
Global report letters correct[c] (max=100)	70 (15)	73 (17)
Partial report[c] (max=50)	36* (8.8)	41 (4.6)
Visual memory pictures[d] (max=32)	21.5* (6.0)	17.4 (5.5)
Visual memory designs[d] (max=32)	17.6 (5.05)	15.1(4.9)
Greek measures		
	Monolinguals (N=30)	
Spoonerisms[e] (max 32)	14 (4.9)	12 (6.5)
RAN[f] (secs)	53**** (15.4)	76 (19.1)
Global report arrays correct[g] (max=20)	4* (4.5)	1.5 (3.0)
Global report letters correct[g] (max=100)	65** (15)	52 (15)
Partial report[h] (max=45)	34 (7)	34 (6.4)
Visual memory pictures[i] (max=32)	17.9 (4.7)	17.4 (5.5)
Visual memory designs[i] (max=32)	15.9 (5.5)	15.1(4.9)

Note: [α]PhAB, (Frederickson et al., 1997), [b]Rapid automatized naming (PhAB, ibid) [c]Letter report tasks, adaptation from Bosse et al. (2007) for English, [d]Visual memory tasks, Athena Test (Paraskevopoulos et al., 1999), [e]Greek spoonerism task adapted from PhAB, [f]Rapid automatized naming in Greek adapted from PhAB, (ibid), [g]Letter report tasks, adaptation from Bosse et al. (2007) for Greek,[i]Visual memory tasks, Athena Test (ibid), * p<.05, ** p<.01, ****p<.0001, p values refer to comparisons between monolinguals and bilinguals

Interrelationships among variables controling for age

Partial correlations between spelling and the other measures were calculated for the monolingual and bilingual children; first, partial correlations for English spelling for the monolingual English children and bilingual children are presented and then for the monolingual Greek-speaking children. Reading measures were not considered in the analyses due to ceiling performance.

Monolingual English group

For English monolingual children's spelling scores, significant associations were obtained with letter report arrays and letters correct. Additionally spelling scores were significantly correlated with those for both irregular and nonword reading. Letter report task scores were not significantly associated with PA, visual memory tasks or with scores for RAN. The correlations are presented in Table 33.

Table 33: *Partial correlations between English spelling accuracy and scores on other assessments for the English monolingual children in Study 3*

	1	2	3	4	5	6	7	8	9	10	11
Spelling	-										
Non-verbal reasoning	.13	-									
Reading irregular words	**.93******	.13	-								
Non-word reading	**.56***	.02	**.62****	-							
Spoonerisms	.11	-.22	.10	.08	-						
Global report total arrays correct	**.66****	.25	**.63****	.45	-.05	-					
Global report total number of letters correct	**.69*****	.14	**.64****	.40	-.07	**.94******	-				
Partial report	.03	.08	.09	.16	.06	.16	.16	-			
RAN Pictures	-.22	-.27	-.16	-.35	**.52***	-.09	-.09	.27	-		
Visual Memory Pictures	-.10	.36	.02	.12	-.38	-.26	-.28	.13	**-.57***	-	
Visual Memory Designs	-.07	.12	-.10	.15	.25	-.37	-.34	-.18	-.32	**.50***	-

* = *p*<.05, ** = *p*<.01, *** = *p*<.001, **** = *p*<.0001

Looking also into the association between irregular word reading and letter report, a significant correlation was found with the scores for the letter report tasks, but not with spoonerisms. Nonword reading accuracy was not associated with letter report tasks.

Bilingual group

The results for the bilingual children are not dissimilar from those for the bilingual older children, as children's spelling score after controlling for age did not correlate with any of the critical variables, which might lead one to speculate that other variables, such as vocabulary, are significantly associated with children's single word spelling skill. Global report arrays correct and partial report scores were not significantly associated with PA, RAN or visual memory scores. Letter report tasks correlated highly with each other. Irregular word reading was significantly associated with non-verbal-reasoning. Nonword reading was not significantly associated with any of the tasks. The results are given in Table 34.

Table 34: *Partial correlations between English spelling accuracy and scores on other assessments for the bilingual children in Study 3*

	1	2	3	4	5	6	7	8	9	10	11
Spelling	-										
Non-verbal reasoning	.19	-									
Reading irregular words	.39	**.61***	-								
Non-word reading	.11	.04	.40	-							
Spoonerisms	.34	-.15	.36	-.18	-						
Global report total arrays correct	.30	-.17	-.16	.18	-.36	-					
Global report total number of letters correct	.03	-.26	-.25	-.00	-.40	**.89******	-				
Partial report	-.33	-.43	-.22	.28	-.31	**.59***	**.69***	-			
RAN Pictures	-.08	-.34	-.46	.19	-.29	-.13	-.21	.01	-		
Visual Memory Pictures	.29	-.47	.01	-.24	.41	.44	.48	.38	-.41	-	
Visual Memory Designs	.01	.26	-.18	.21	-.42	.42	.12	.16	.14	-.32	-

* = *p*<.05, **** = *p*<.0001

Greek monolingual group

For Greek monolingual children's spelling scores, significant associations were obtained with global report arrays correct and partial report, as well as with RAN. Global report total number of arrays correct was significantly associated with visual memory and RAN but not with PA. Global report total number of letters correct was significantly associated with visual memory but not with PA or RAN. Partial report score was significantly associated with RAN. The results are presented in Table 35.

Table 35: *Partial correlations between Greek spelling accuracy and scores on other assessments for the Greek monolinguals in Study 3*

	1	2	3	4	5	6	7	8	9	10	11
Spelling	-										
Non-verbal reasoning	.22	-									
Reading accuracy	.20	-.05	-								
Non-word reading	.43	.24	.76**	-							
Spoonerisms	.37	.65*	-.39	-.06	-						
Global report total arrays correct	.53*	.52	.16	.27	.19	-					
Global report total number of letters correct	.43	.38	-.00	.16	.19	.88***	-				
Partial report	.65*	.09	-.19	-.08	.25	.60*	.50	-			
RAN Pictures	-.82***	-.16	-.34	-.40	-.08	-.55*	-.44	-.71**	-		
Visual Memory Pictures	.51	.66*	-.12	.11	.48	.81***	.80***	.43	-.32	-	
Visual Memory Designs	.46	.62*	-.19	.07	.57*	.66*	.71**	.52	-.33	.87****	-

* = p<.05, ** = p<.01, *** = p<.001, **** = p<.0001

Partial correlations controling for PA

In order to investigate whether letter report per se was associated with spelling or if this relationship was mediated by PA, a partial correlation analysis controlling for PA was performed. Global report was still significantly associated with spelling skill for all three groups, correlations were r=.47, p<.01 for the monolingual English children, r=.46, p<.05 for the monolingual Greek children and r=.55, p<.01 for the bilingual children. The findings indicate, in agreement with those of Bosse and Valdois (2009) for reading, that letter report contributes to spelling performance independently from phonological processing. Next a summary of correlations across studies will be presented.

Summary of correlations across studies

In order to determine the strength of the correlations across studies and age groups correlations between single word spelling and the different variables are presented in Table 36.

Table 36: *Partial correlations (controlling for age) across Studies 1, 2a, 2b and 3 between single word spelling score and different child related variables*

	Monolingual English				*Monolingual Greek*				*Bilingual*						
Group	Young Study 1	Young Study 2a	Old Study 1	Old Study 3	Young Study 1	Young Study 2a	Old Study 1	Old Study 3	Young Study 1	Young WG Study 2a	Young SG Study 2a	Old Study 1	Old WG Study 2b	Old SG Study 2b	Old Study 3
Non-verbal reasoning	.51**	.52**	.49**	.29	.33	.25	.42	.22	.03	.74***	.36	.38	.81***	.29	.19
Blending	.43*	.43*	.36	-	.53***	.38*	.35	-	.56**	.19	.83***	.21	-.25	.78**	-
Spoonerisms	.34	-	.21	.11	.45**	-	.38	.37	.45*	-	-	.27	-	-	.34
Global report total arrays correct	-	-	-	.66**	-	-	-	.53*	-	-	-	-	-	-	.30
Global report total number of letters correct	-	-	-	.69***	-	-	-	.43	-	-	-	-	-	-	.03
Partial report	-	-	-	.03	-	-	-	.65*	-	-	-	-	-	-	-.33
Visual memory for Pictures	.39*	.42*	.62***	-.10	.49**	.23	.48	.51	.19	.12	.49*	.18	.63*	.11	.29
Visual memory for Designs	.23	.11	.14	-.07	.32	.15	.70**	.46	.24	.59**	-.02	.06	.63*	.36	.01

Comparisons of partial correlations controlling for age across studies indicate that for English spelling both PA and visual memory are important variables, at least for the younger children. For older children, lexically related variables such as letter report and visual memory are more prominent. The correlation coefficient for spelling and visual memory for the older monolingual English children in Study 1 is smaller than the correlation coefficient between spelling and letter report tasks in the same age group of Study 3, however the difference is not statistically significant $p>1$.

For the young and old monolingual Greek speaking children results are not dissimilar from the ones obtained for the monolingual English speaking children. For the young children both PA and visual memory are important components of accurate spelling. Whereas for the older children in Studies 1 and 3 visual memory and letter report tasks have a more profound role.

For the young bilingual children assessed in Study 1 only PA is a significant determinant of spelling accuracy and when the children were split according to Greek literacy awareness groups a clear dissociation between visual memory and PA emerged and this was replicated one year later. The older bilingual children of Study 1 and 3 also showed a similar pattern as for bilinguals in both studies no associations were found with the critical variables. However, a strong correlation was found between spelling and vocabulary in Study 1 indicating the importance of vocabulary for children learning a second language.

In order to investigate further the association between PA, letter report and spelling performance regression analyses were conducted.

Regression analyses

Simultaneous multiple regression analyses were conducted for the monolingual and bilingual groups with scores from spelling in the 60-word list as the criterion variable. Scores for global report arrays correct and PA were predictor variables (scores for the former were used since this one of the three measures of letter report correlated most highly with spelling scores). The overall regression model was significant for the monolinguals, $F(2,29)=9.7$, $p<.001$ and for the bilinguals $F(2,21)=9.7$, $p<.001$. A summary of the analyses is provided in Table 37.

Table 37: *Simultaneous multiple regression analyses with spelling scores as the criterion variable in Study 3*

	Monolingual				***Bilingual***			
	English Spelling							
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2
Global report	.86	.31	**.46****	.42	1.1	.38	**.48****	.51
Phonological ability	.64	.38	.28		1.2	.54	**.40***	
	Greek Spelling							
Global report of arrays	4.2	1.3	**.55****	.55				
Phonological ability	.59	.27	**.37***					

Note: [a]Unstandardized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, *p<.05, **p<.01

Monolingual English spelling was predicted by global report arrays correct and not PA. Letter report explained 36% of variance in English spelling, whereas PA explained 25%. A different result was observed for the bilingual children as both PA and letter report were significant predictors. PA explained 29% of variance and letter report explained 36% of variance.

The same analysis was conducted for the monolingual Greek children. The overall regression model was significant, $F(2,23)=9.7$, $p<.01$. Letter report was a significant predictor as well as PA. Letter report explained 42% of variance and PA explained 27% of variance in spelling.

The same analyses conducted with RAN and global report arrays correct as the predictor variables found that only global report predicted children's spellings (the result is included in Appendix B) and the result did not differ for the bilingual children.

Discussion

Study 3 aimed to investigate for the first time in monolingual English and Greek and bilingual children whether letter report is associated with spelling, as has been shown to be the case for reading by Bosse and Valdois (2009). A comparison of the results for Greek and English is of interest as Greek is transparent for reading while English is opaque. Accordingly, one would expect that phonological ability would be more strongly associated with spelling performance in Greek than English.

The results of the partial correlational analyses indicated that letter report performance was associated with irregular reading in the English monolingual group (in agreement with Bosse et al. 2007 and Bosse and Valdois, 2009), and also with spelling in both monolingual groups. Partial letter report was not significantly associated with spelling scores for the English monolingual group, although the two measures of global report (arrays correct and letters correct) were. For the Greek monolinguals global report arrays correct and partial report were significantly associated with spelling. In this study visual memory scores were not significantly associated with spelling for the monolingual and bilingual groups.

The role of letter report in spelling did not seem to be mediated by PA as when partial correlations were conducted controlling for PA the correlation of letter report scores with spelling remained significant. These findings are not different from the results of Bosse et al. (2007) and Bosse and Valdois (2009) who suggested that simultaneous multi-character processing ability is a core component (of reading) independently from PA.

In the regression analyses global letter report scores were found to be a strong predictor of English spelling for the monolingual English children, although PA scores were not. The same pattern was not found for the Greek-speaking children, as both PA and letter report were significant.

In Study 1 the findings for the older children are similar to the results observed in the present study. The regression results from Study 1 and this study show that the effect of the ostensible lexical variable (visual memory in Study 1 and letter report in the present study) was significant in the English monolingual group while the effect of PA was not. For the Greek monolingual older children in Study 1 and Greek monolingual group in Study 3 both a lexical and a sublexical variable predicted the children's spelling performance. It would be informative to carry out Study 3 with younger children, comparable in age to the younger children in Study 1.

In the regression analyses for spelling in English for the bilinguals, both PA and global report arrays correct were significant predictors. The pattern observed is thus more akin to that of the Greek monolingual children than that of the English monolinguals. The results of this study, in agreement with those of the previous studies, indicate effects of both lexical and sublexical variables for the bilinguals, interpreted in the previous studies as due to learning to read and spell in transparent Greek. The findings are not different from other biliterate studies where evidence was found of language transfer in both behavioural and fMRI studies (c.f. Mumtaz & Humphreys, 2001, 2002; Nelson et al. 2009; Perfetti & Liu, 2005, see section 2.5.1). In Study 4, presented next, further evidence that simultaneous multi-character processing ability is associated with lexical rather than sublexical literacy processes is provided in the final case study report.

Interim summary

The group studies with typically developing monolingual and bilingual children indicated several important variables for spelling in English and Greek. These were phonological processing, visual memory, letter report, RAN, morphological awareness and receptive vocabulary. Analyses carried out indicated that DR theory can be a useful theoretical model for identifying different cognitive processes in spelling acquisition for TD children. If the interpretation of the group studies is reliable then it should be possible to identify deficits in these processes in children who have literacy difficulties. A strong source of evidence is considered to be intervention case studies, as these can test and inform theoretical models controlling effectively for mediating variables that affect the observed associations (Nickels et al., 2010). The aim of the intervention case studies reported next was to test further the efficacy of the theoretical model and to provide further evidence of causal relationships, as well as to obtain evidence for clinically and educationally useful training programmes for those with literacy difficulties.

7. Study 4: Case studies and interventions with children with reading and spelling difficulties

7.1. Introduction

Following identification of variables affecting spelling in the group studies with typically developing Greek monolingual and bilingual children a series of single case studies was conducted with children with spelling and reading difficulties. Single case studies have been carried out to complement evidence from studies with typically developing readers and spellers (Studies 1 and 2) and to try to provide evidence for the dissociation of processes involved in reading and spelling. Also intervention studies have been used to provide evidence for the association of literacy deficits and underlying impairments following similar studies conducted with children with atypical reading and spelling (e.g., Brunsdon et al., 2005; Kohnen, Nickels, Brunsdon, & Coltheart, 2008a; Kohnen et al., 2008b; Kohnen, Nickels, & Brunsdon, 2010). Prior to presenting these studies and potential causes of reading and spelling difficulty a description of a bilingual DR model of reading will be presented as children participating in the case studies reported were mainly multilingual. Inclusion of this model was considered important as a DR model of bilingual spelling was discussed in section 2.5. and reading measures were also included in the case reports presented.

7.1.1. *A model of bilingual word recognition*

Klein and Doctor (2003) proposed a model of bilingual printed word recognition which is also based on the DR model (see Figure 7). According to this there are language specific orthographic input and output lexicons to accommodate each linguistic code during word recognition and a phoneme–grapheme translator system which exists independently for the different languages. The model also has a language specific orthographic output lexicon which is used for word production. The researchers based their model on research using words in English and Afrikaans. They conducted a lexical decision task and interlingual homophones and homographs were included in their stimuli. The participant needed to decide incase the stiluli was a real word if it belonged in the Afrikaans or English language. The reaction time for interlingual homophones was slow and performance was error prone. Klein and Doctor argued that this indicates that the grapheme-phoneme translator is actively engaged by both languages during word recognition. The researchers tested their model to see whether it would be able to account for phonological dyslexia (Doctor & Klein, 1992). They assessed a simultaneous bilingual child, KT, who was of average intelligence and was dyslexic in both languages in which she was literate (Afrikaans and English). KT was assessed on reading words and nonwords in English and Afrikaans; she exhibited a severe difficulty with nonwords in both languages. Even though Afrikaans is a transparent language her sublexical route appeared to be so compromised that she was not able to take advantage of the transparency. The authors concluded that KT's difficulty indicated a deficit of the language independent grapheme-phoneme translator and that the proposed model can also account for bilingual atypical reading.

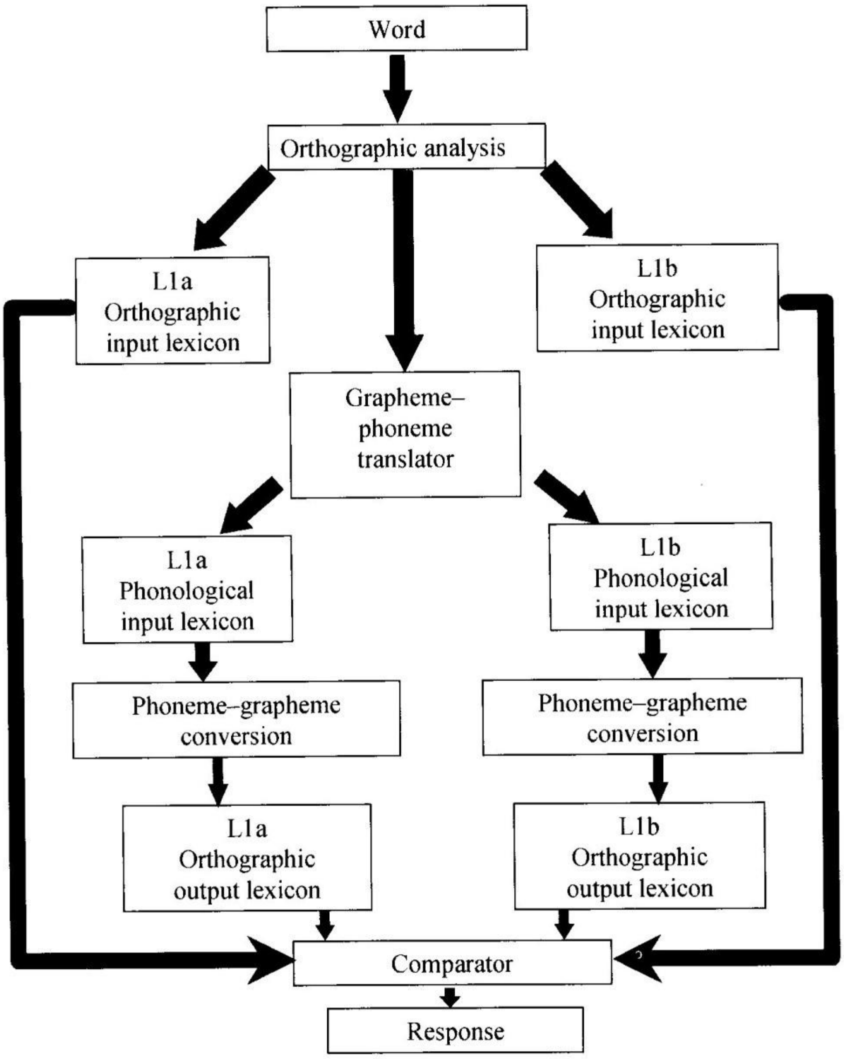


Figure 7: *Model of bilingual word recognition and production, and reading aloud. Source: Klein and Doctor (2003, pp. 114)*

Doctor and Klein's model was derived from empirical data on balanced bilinguals and, as a result, they suggest that the grapheme-phoneme translator is common for both languages while lexical activation is triggered in parallel for both languages. However, the latter was questioned by Dijkstra, Grainger and Van Heuven (1999) who claimed that although the study provides some evidence that phonology of both languages is active while word recognition is taking place the large number of pseudohomophones in the stimuli might have caused a high level of inhibition in the reading task. Next differences on the acqusition of reading skill by typically and atypically developing children learning different orthographies will be presented. Focus will be on reading as differences on the acquisition of spelling in children learning different orthographies were already presented in section 2.5.1.

7.1.2. *Cross-linguistic variance in the acquisition of reading skill in typically and atypically performing school populations*

Several studies have been conducted that indicate that sublexical skills emerge faster in more transparent orthographies. Seymour et al. (2003) conducted a cross-language study involving non-word reading, word reading and letter knowledge measures in young children from thirteen different countries. The languages covered were English, which has a deep orthography, and twelve other languages with orthographies of varying transparency. The results revealed that orthographic depth and syllabic structure affected the time necessary to develop word and non-word reading accuracy for each language. English syllable structure consists of complex CVC (consonant -vowel-consonant) forms, as discussed in section 2.2. English speaking pupils needed 2.5 years of instruction to match the level of most other European orthographies. Greek speaking pupils by the end of first Grade were able to successfully read novel and familiar words (see also, Harris & Giannouli 1999). Figure 8 classifies writing systems according to their orthographic and syllabic complexity (Seymour et al., 2003).

	type of writing system	phonological unit	examples	transparency level
more transparent	alphabetic	phoneme	Finnish, Italian English, French	more ↑ less ↓
↑	syllabic	syllable/mora	Japanese kana Tibetan	more ↑ less ↓
↓	consonantal	consonant	Arabic, Hebrew	
less transparent	morphemic	1 syllable 1 (+) mora(s)	Chinese hanzi Japanese kanji	more ↑ less ↓

Figure 8: *Classification of writing systems in terms of syllabic and orthographic complexity (Seymour et al. 2003, pp. 146)*

Similar findings were reported in other cross-linguistic studies comparing English to more consistent orthographies (e.g. Goswami, Gombert, & Barrera, 1998; Frith, Wimmer, & Landerl, 1998; Cossu, Cugliotta, & Marshall, 1995; Ellis et al., 2004). However, these and the aforementioned studies could not control for socio-cultural differences (such as, school systems, curricula, teaching methods, demographic distributions, socioeconomic background). There were also differences in the age of the participating children (for example in the Seymour et al. study English children were, on average, 5.59 years and the oldest children (Norwegian) were 7.94 years) and number of children participating in each language group. Bruck, Genesee, and Caravolas (1997) tried to address these methodological issues by conducting a longitudinal study in which children were from the same area. They still found that English speaking children were 24% behind French children on real word reading and 27% behind on nonword reading. Similarly, Spencer and Hanley (2003) collected data from Welsh and English children closely matched in age who lived in the same area. The researchers found that children speaking Welsh (which has a transparent orthography) performed significantly better in reading of words and non-words and in PA tasks than their English counterparts. So orthography is a factor which determines development of reading skills.

Turning now to evidence from atypically reading school populations further support for the latter view was provided by Hanley et al (2004). Three years after their initial study (Spencer & Hanley, 2003), Hanley et al. re-assessed the same Welsh and English children's reading of words and found that they still differed (they were now 10 years-old). Welsh children read 103 out of 110 words accurately while English children read 88. Reading of nonwords was no longer significantly different. Further analysis of the reading performance of the lowest quartile groups of Welsh and English children indicated that the least able quartile of English children was well below the least able quartile of Welsh children (see Figure 9)**.**

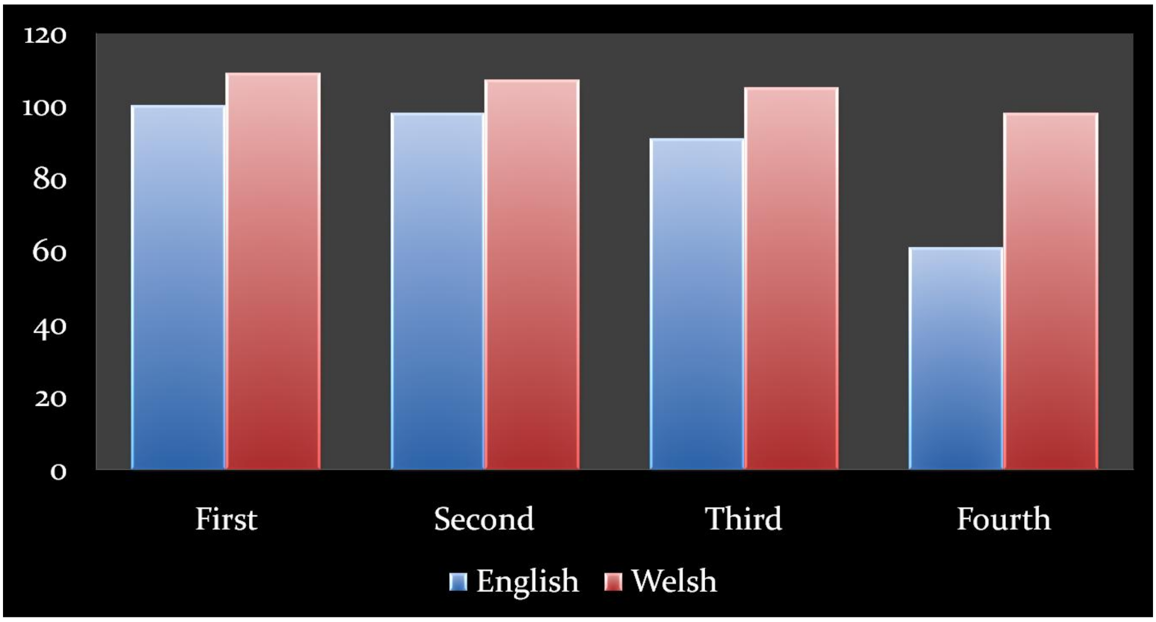


Figure 9: *The number of real words read correctly (max=110) by quartile groups of Welsh and English children (Spencer et al., 2004, pp. 14)*

The significance of orthographic characteristics for literacy acquisition of dyslexic and non-dyslexic children bilingual in Hindi and English was also discussed by Gupta and Jamal (2007). They compared the performance of a group of 30 bilingual dyslexic children (mean age 103.07 months) with that of a typically developing bilingual group (mean age 102.97 months). Children were assessed in reading lists of matched words in Hindi and in English. In Hindi typically developing children made predominantly nonword errors while in English they made more real word substitutions, indicating that the transparency of Hindi led the children to rely on sublexical processes for reading, while the opaqueness of English led them to rely more on word-based processes. The situation was different in the case of the dyslexic children. They seemed to be unaffected by transparency and relied on sublexical processes for both languages. This is not an optimal strategy for English. The researchers suggest that poor readers transfer an optimal strategy from the L1 to the L2 by producing overgeneralisation. However, this is not always the case. See case study presented by Doctor and Klein, (1992) in previous section.

Similarly, Da Fontoura and Siegel (1995) in a study with 37 bilingual Portuguese and Canadian speaking children (age range 9 to 12 years) reported that bilingual (reading disabled) RD children had similar performance to monolingual RD children in English word reading and working memory tasks but higher scores in an English pseudoword reading task and in spelling. The result indicates a positive transfer from transparent Portuguese to opaque English. Abu-Rabia and Siegel (2002) in a cross-linguistic study with English-Arabic children with learning disabilities found that RD children scored higher in a non-word English reading and spelling task than their mono-scriptal English counterparts. This also emphasises the importance of orthography for learning to read and spell in RD children. It also indicates that phonological processing skills, such as nonword reading, are not such a burden for RD children learning transparent orthographies as for English RD children.

Turning now to case reports conducted with bilingual participants there are findings which support that difficulties manifested in one language will be also apparent in the other (Geva, 2000); however it also seems that characteristics of orthography regulate the degree of the deficit in each writing system. For example, Masterson, Coltheart, and Meara (1985) reported FE who exhibited surface dyslexia/dysgraphia in both languages (English and Spanish), despite the different characteristics of the two languages (English being opaque for both reading and spelling and Spanish being transparent for reading but rather less transparent for spelling). In English, irregular word reading was impaired compared with regular word reading, while in Spanish, FE was able to read all of the words without errors. However, his spelling was very poor and exhibited a preponderance of phonologically appropriate errors. Alternatively, Wydell and Kondo (2003) demonstrated in their case A.S., an English-Japanese bilingual, that he had dyslexia in the deep orthography of English but did not show manifestations of reading difficulty in Japanese. The authors interpreted their findings as indication that A.S.'s phonological deficit could not affect reading in Kana, a very transparent orthography, or Kanji which was not phonemically decodable.

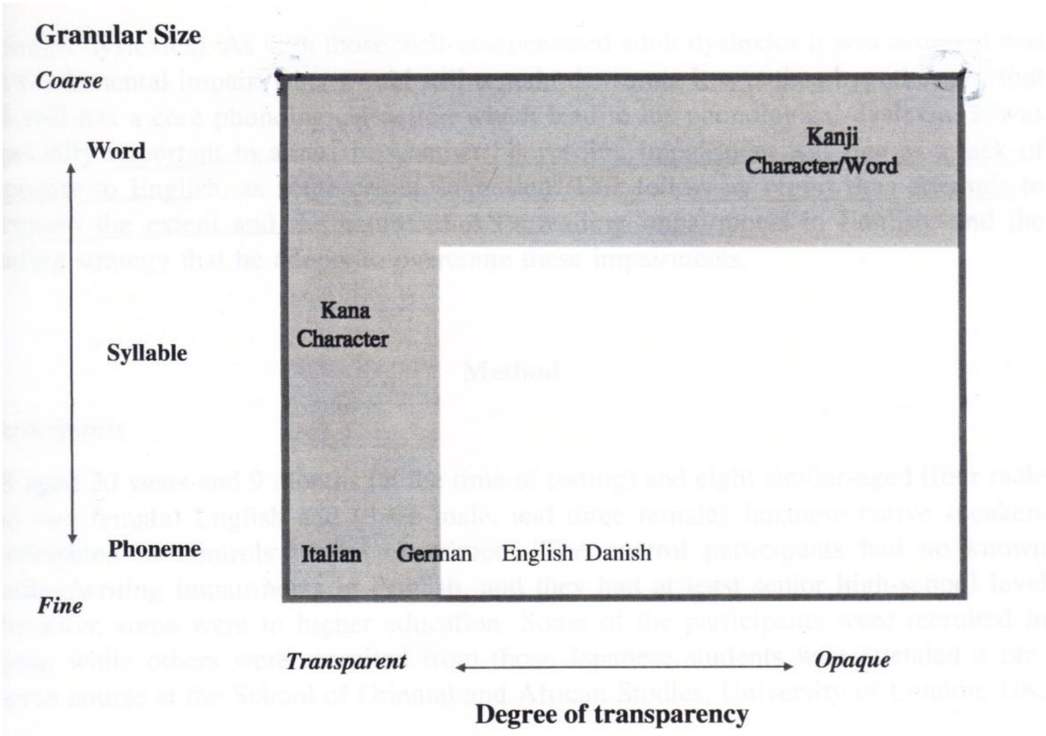


Figure 10: *Granularity and Transparency Hypothesis (Wydell & Kondo, 2003, pp. 38)*

Note: The shaded area is the most transparent according to the researchers.

Wydell and Kondo (2003) explained the performance of A.S. according to the Hypothesis of Granularity and Transparency (Wydell & Butterworth, 1999). This postulates that orthographies can be classified on a two dimensional continuum where the horizontal represents the transparency and the vertical the granularity (phoneme, syllable, word) (see Figure 10). Where the writing system is transparent but employs large orthographic units, such as syllables (as in Japanese Kana), the incidence of dyslexia is low. Similarly, where the orthography is deep and is represented by large orthographic units (such as whole words, as in Japanese Kanji) again the incidence of dyslexia will be low, as phonology is not a prerequisite in learning to read and write in this writing system. They base their assumption on research findings deriving from a nationwide survey in Japan investigating the incidence of dyslexia (Kokuritsu Tokushu-Kyoiku Sougou Kenkyujyo (The National Research Institute of Special Education, 1996)) which had shown that cases of dyslexia range between 2.28% to 1.80% of the school population in Grades 2 to 6 with cases decreasing as children grow older. This is in sharp contrast to what has been found for English, as Snowling (2000) reported that the incidence of dyslexia ranges around 10% of the school age population.

Findings indicate that reading deficit will be moderated by transparency of the writing system. Therefore, it seems that children learning a transparent language will achieve better performance in reading than children learning an opaque language such as English. However, this might not always be the case as it was shown by Doctor and Klein's (1992) English-African case study. Next potential causes of reading and spelling difficulties in developmental dyslexia/dysgraphia will be discussed.

7.1.3. *Potential causes of reading and spelling difficulty*

Developmental dyslexia/dysgraphia is a reading and spelling disorder encountered by children and adults and identified as a difficulty in learning to read and spell (Fletcher, 2009). Research in diverse orthographies has indicated that developmental dyslexia is not only restricted to the English language, although most of the research with dyslexic participants has been carried out in English. The severity of symptoms has been shown to be related to language characteristics, including the consistency of letter-sound relationships.

Turning now to possible causes of poor reading and spelling it is difficult to suggest a single aetiology. There is evidence that a cardinal symptom of phonological dyslexia is a deficit in PA as suggested by the "Core Phonological Deficit Hypothesis" (Snowling, 1995). Evidence has also accumulated showing that RAN is also associated with spelling and reading ability (see section 3.2. for a review and Studies 1 and 3 of the current thesis). However, a growing number of researchers are disputing the widely held view that the core deficit for dyslexia is in phonological processing (see Vidyasagar & Pammer, 2010 for a review). Studies have also examined the role of visual processing deficits in developmental dyslexia\dysgraphia (see Boden & Giaschi, 2007, for a comprehensive account). Although there is research indicating visual temporal processing problems in developmental dyslexia (Farmer & Klein, 1995), it has been debated whether these are the outcome or the cause of reading difficulty (Hutzler, Kronbichler, Jacobs, & Wimmer, 2006). Ramus and Ahissar (2012) in a review of data on normal and poor performance in dyslexic participants claim that magnocellular dysfunction (problems with the ability to process fast changes in the visual modality, Livingstone et al., 1991) and sluggish attention shifting (a slowing of attention engagement/disengagement, Hari & Renvall, 2001; Faccoetti et al., 2010; Lallier et al., 2009; 2010) tend to co-occur with phonological problems.

As a line of evidence, studies of participants with dyslexia\dysgraphia have also looked at the role of visual memory, simultaneous multi-character processing and RAN in reading and spelling. Research looking at visual memory deficits as an alternative potential cause for developmental reading and spelling difficulties has been reported. It could be that visual memory might play a role in languages such as Greek and English (Niolaki & Masterson, 2012 and Studies 1 and 2 in the current thesis), due to spelling inconsistency (Spencer et al., 2010; Spencer, 2010). This inconsistency might be expected to discourage use of phonological processes and encourage more reliance on whole-word processes. Goulandris and Snowling (1991) and Romani et al. (1999), see section 3.2 for a review, also investigated the role of visual memory in association with spelling skill in developmental dysgraphia. The aforementioned researchers reported case studies of developmental dyslexics who exhibited a deficiency in visual memory span and poor encoding of serial order in a visual memory task, respectively. Goulandris and Snowling suggested that the visual memory deficit may have led to the difficulty in forming detailed orthographic representations. Romani et al. (2008) concluded that phonological dyslexics are more deficient in phonological ability, whilst surface dyslexics possess impaired lexical representations as reflected in poor performance in a visual sequential memory task.

There is also some evidence that a simultaneous multi-character processing deficit may be involved in surface dyslexia (Bosse et al., 2007, see Chapter 6 for a review). Bosse et al. (2007), found in a large cohort of dyslexic children, using partial and global letter report tasks, that some of the participants showed a selective letter report impairment and some a phonological deficit. Case studies are also reported with a selective letter report impairment or PA deficit (see Chapter 6 for a review). The association of surface dyslexia/dysgraphia and simultaneous multi-character processing impairment is relevant to the present case studies since, as will be reported later, children were found with and without impairment of letter report depending on their literacy impairment.

Castles and Coltheart (1993) investigating variates of developmental dyslexia in English schoolchildren provided evidence that surface and phonological dyslexia were relatively common amongst English speaking dyslexic children. They assessed 106 children (53 with dyslexia age range 7 to 14 years, and 53 typically developing (TD) readers matched with the dyslexics on age, mean age: 11;2) using irregular words and nonwords. The researchers carried out simple regression analyses with predictor variables the age of the control group and outcome the irregular word reading score on one occasion and the non-word reading score on the other. This first regression was carried out only on data from the control group.The progression in reading (of both irregular words and non-words) of children with typical reading development was used as the basis for the classification of the dyslexic children into subtypes: being poor in reading irregular words or non-words or both. The researchers used the criterion of 90% confidence interval (CI). Eighteen dyslexics (34%) fell below the CI for non-word or irregular word reading but were within the TD range for the other task. Ten dyslexic children exhibited the pattern of surface dyslexia (unimpaired non-word reading but impaired irregular word reading) and 8 dyslexic children showed the pattern of phonological dyslexia (unimpaired irregular word reading but impaired non-word reading). The rest of the children (N=32 cases) were impaired in both routes but still they were more impaired in one of the two.

Manis et al. (1996) carried out a similar study to that of Castles and Coltheart with 51 dyslexics, as did Stanovich, Siegel, and Gottardo (1997). However, in both these studies when reading age control children were considered the number of surface dyslexic children was reduced in contrast to the phonological dyslexics. The researchers concluded that surface dyslexia was a delay in reading development. There was also critique regarding whether the same theoretical model can (or should) be used for both acquired dyslexics, who had developed reading and spelling abilities and lost them after brain injury, and developmental dyslexics, who had never been able to acquire literacy skills (Ellis, 1985). A number of authors have argued that the evidence for the discrete subtypes is contentious, or else can be explained in terms of individual differences in terms of instruction or intervention (see for example, Bryant & Impey, 1986; Wilding, 1990; Thomson, 1999; Sprenger-Charolles & Serniclaes, 2003; Stanovich et al., 1997; Sprenger-Charolles et al., 2011).

Douklias, Masterson, and Hanley (2009) reported cases of phonological and surface developmental dyslexia in Greek. They assessed 84 Greek-speaking children aged 9-12 years and identified four cases of poor readers showing selective reading difficulties. The researchers using the regression methodology from Castles and Coltheart (1993), used nonword reading accuracy in order to identify children with a deficit only in the phonological route, and single word reading speed to identify a selective deficit in the lexical route. They justify the use of real word reading speed, instead of accuracy, due to the absence of irregular words for reading in Greek. Thus, accuracy will reach ceiling for real words but reading speed will be slow due to the fact that the children rely on sublexical processes. In summary, according to their classification, children with a selective phonological deficit in Greek will have difficulties in reading nonwords but their reading speed will be within the normal range whereas children with surface dyslexia will have a selective deficit in reading speed but their nonword reading accuracy will be within the normal range. Two of the children in the Douklias et al. study exhibited poor nonword reading accuracy, and two exhibited slow familiar word reading but unimpaired nonword reading. The authors made a series of predictions about the performance in spelling and in phonological awareness tasks of the four children, on the basis of the characteristics of surface and phonological dyslexia in English speaking cases, and the fact that irregular words do not exist for reading although they do for spelling in Greek. Douklias et al. found that the children with the profile of surface dyslexia showed significant difficulty spelling irregular words but not nonwords, while the profile of phonological dyslexia was associated with the opposite pattern. In addition, the two children with a profile of phonological dyslexia exhibited worse performance in phonological awareness tasks (blending and deleting syllable and phonemes, spoonerisms) than age matched control children. One of the two children with the profile of surface dyslexia did not show impaired performance in the phonological awareness tasks; however the other child with this profile was worse than controls in phoneme and syllable deletion, indicating a mild phonological deficit. Finally, both children with the profile of surface dyslexia showed worse performance in rapid naming tasks than the control children, while the phonological dyslexics were unimpaired in these tasks. Douklias et al. speculated, in line with previous suggestions of Manis et al. (1999), that rapid naming deficits and surface dyslexia may reflect the same underlying difficulty – one that involves a difficulty in forming arbitrary associations, such as those that must be learnt between irregular words and their pronunciations.

Friedmann and Lukov (2008) investigated the characteristics of surface dyslexia in an opaque orthography, Hebrew in seventeen dyslexic participants (age range 10-43). The researchers conducted various tasks tapping the lexical processing (such as, lexical decision, homophone discrimination, comprehension tasks and reading of items called as *potentiophones*, items with different phonology, orthography and semantics, for example, *know* and *now,* but when read can be easily confused). The researchers concluded that varieties exist even between participants with surface dyslexia, as they found surface dyslexics who had only difficulties in orthographic output with intact lexical decision but difficulties in semantics. They also reported surface dyslexics with difficulties in orthographic input, who could not perform in lexical decision or homophone tasks. Finally, they mention that the highest error rate was for potentiophones and this was observed for all surface dyslexic participants.

In developmental dyslexia/dysgraphia it is hard to suggest a single aetiology. Researchers have stressed the importance of intervention case studies in helping us to understand more about underlying deficits. Intervention studies are the focus of the next section.

7.1.4. *Intervention studies*

Nickels et al. (2010) recently highlighted the significance of intervention studies in informing theories of cognitive processes. Indeed there have been several such studies (e.g., De Partz, Seron, & Van Der Linden, 1992; Nickels, 1992; Rapp & Kane, 2002; Biedermann & Nickels, 2008a & b; Brunsdon et al., 2005; Kohnen et al., 2008a&b; Kohnen et al., 2010). A good deal of evidence derives from studies of people with acquired dyslexia and dysgraphia, for example, Rapp and Kane (2002) investigated treatment of spelling in relation to improving the capacity of the graphemic buffer, and Biedermann and Nickels (2008 a, 2008b) investigated whether or not homophones have independent representations by the means of intervention studies.

The intervention studies reported next have involved targeting the potential locus of the reading or spelling deficit, that is, training in grapheme-phoneme rules in the case of developmental phonological dyslexia, or improving word-specific knowledge in the case of developmental surface dyslexia. For example, Brunsdon et al. (2005), see also section 2.3.2.1, conducted a study with a twelve year old child, M.C., who had developmental surface dysgraphia. The spelling intervention targeted the lexical route using techniques that had been successfully employed with acquired surface dysgraphics (flashcards with and without mnemonic aids). Improvement in MC's irregular word spelling was found following a four-week training that involved 308 irregular words. Words were closely matched in terms of spoken and written frequency and number of letters. The investigators also found that untreated irregular words improved over the course of the intervention and many of these showed gradual improvement in degree of similarity to the correct spelling. The authors suggest their results indicated improved access to lexical representations resulting in less reliance on sublexical processing. Regarding the efficacy of using mnemonics as part of the intervention (training of set 2 but not set 1 or 3) findings did not provide evidence that this particular technique was more effective than the flashcard without mnemonics technique. Kohnen et al. (2008b), followed up the results reported by Brunsdon et al. by conducting an intervention study with a nine-year-old child with developmental surface dysgraphia. The researchers used the same intervention programme as Brunsdon et al., with the aim of investigating the nature of treatment generalisation. Improvement was again found for treated and untreated irregular words. Untreated words were more likely to improve if they had many orthographic neighbours and if they were of high frequency. The authors discuss the results in terms of strengthening of connections between lexical entries and the graphemic buffer.

Intervention case studies targeting either the lexical or the sublexical route with developmental dyslexics with mixed dysgraphia\dyslexia have also been conducted. Brunsdon, Hannan, Coltheart, & Nickels (2002a) carried out such a study with a ten-year-old child, TJ. TJ's reading and spelling skills were significantly lower in comparison to what was expected for his age, as he had a standard score of 56 for reading and 64 for spelling in the Differential Ability Scales (DAS, Elliot, 1990). TJ was also not able to score in nonword reading, indicating a significant deficit in sublexical processes. But also TJ's lexical route was malfunctioning according to his impoverished sight vocabulary (for example, he was not able to read consistently correctly high frequency words such as *can* or *at).* The intervention targeted reading and was aimed at improving lexical processing. It employed a flashcard method over ten weeks, with ten new words per week. The intervention resulted in improvement of word (but not nonword) reading skill and gains were sustained over time. The researchers also reported generalisation to untrained items and to spelling. In this study the researchers also used mnemonic aids for reading in Experiment 1 but not Experiment 2. The results did not provide support for enhanced improvement due to use of mnemonic aids.

Two studies, conducted by Kohnen et al. (2008a) and Kohnen et al. (2010), targeted improvement of sublexical spelling skill in mixed dysgraphia. In both studies the researchers aimed to improve the split diagraph rule and investigated possible generalisation to untrained items. In the first, Kohnen et al. (2008a) investigated KM.

KM was 8 years and 9 months when testing began, she had bellow age expectations real word and nonword spelling skills and her type of errors indicated difficulties with grapheme phoneme correspondences (for example she frequently misspelt the phoneme /Λ/, she spelled it with an A and consistently misspelled items by adding or omitting the final *e* in words). Kohnen et al. trained the split diagraph rule with KM for two vowels and the vowel grapheme *u*. Generalisation was observed to the other three vowels for the split digraph rule and for untrained nonwords. Similar gains were observed for training the grapheme *u*. For untrained words, improvement occurred but not immediately, indicating that adding new representations take a little longer and show a delayed training effect. The authors concluded that intervention achieved long-lasting improvement in spelling of both trained and untrained items and generalization to reading skill was observed. Kohnen et al. (2010) in a subsequent study tried to replicate Kohnen et al.'s (2008a) results with a second child with mixed dysgraphia, RFL. RFL was an adolescent, 14-years-old at the outset of the study. In spelling and reading he achieved a standard score of 60 and 74 respectively, as assessed by the WIAT (Wechsler, 1992) test. Assessment of irregular word reading and spelling, an index of lexical processing, indicated that his performance was well below the control mean (reading RFL=16, Z=-2.37; spelling RFL=8 comparison group mean=25.4 SD=1.52). The same was observed for nonword reading and spelling, an index of sublexical processing (reading RFL=12, Z=-2.37; spelling RFL=11 comparison group mean=20.8 SD=2.77). The same intervention was not so effective, as generalization did not occur to untrained vowels. The researchers attribute differences in the effectiveness of the intervention to pre-training spelling performance. Prior to the intervention, MK was at floor for the split digraph rule for all vowels; while, RFL performed above ceiling but his awareness of the rule was inconsistent. Kohnen et al. (2010) suggested that for RFL each vowel needed specific training.

Sublexical intervention was also based on the case study of Brunsdon, Hannan, Nickels, and Coltheart (2002b). This targeted sublexical reading of an eight-year-old boy who had mixed dyslexia, DT. DT achieved a standard score of 69 is the DAS (Eliot, 1990) reading test and both his lexical and sublexical route were malfunctioning (irregular word reading=3 out of 30, Z<-2.41 and nonword reading =1 out of 30, Z=-2.27). They aimed to teach grapheme-phoneme correspondences and to train grapheme segmentation and blending of phonemes. The intervention lasted four and a half months and included two different phases of intervention. DT initially practised single letter graphemes by sounding them and each week he had to practise 6 graphemes and revise them daily. As soon as single letter graphemes were securely learned focus were on two-letter grapheme sounding including only those the child failed to read on at least one baseline assessment. Once a week there was a revision of graphemes taught on the previous week. In this training programme and unlike the previous ones conducted by the same researchers DT was taught that a certain grapheme might have more than one equivalent phonemes (for example, that the *c* can be /s/ or /k/) and similarly that a certain phoneme can have more equivalent graphemes (for example, that *ue* and *ew* make the same sound /juː/). Phase 1 of the Brunsdon et al (2002b) intervention programme was also used in the sublexical intervention programmes conducted in the current thesis. Phase 2 included grapheme parsing and phoneme blending of two- and three-grapheme nonwords. Follow up assessments conducted three months post-intervention indicated that grapheme-phoneme knowledge improved dramatically as well as reading of nonwords.

Intervention case studies and group studies with bilingual participants have also been reported. For example, Broom and Doctor (1995a), presented an intervention case study conducted with a bilingual 11-year-old boy SP. SP had developmental phonological dyslexia and the intervention targeted phonological skills. The researchers aimed at improving only his English reading ability but not his Afrikaans. Improvement in sublexical reading processes was found, and generalization occurred to untrained items. Stuart (1999; 2004) conducted a group intervention study with Reception and Year 1 children in London, UK, and the majority of the children were learning English as an additional language (EAL). An experimental group was administered a programme targeting phonological awareness and phonics, based on the Jolly Phonics scheme, and another group received a whole language programme based on Holdaway's (1979) Big Books. The phonics programme was very effective for developing reading and spelling skills of the EAL and monolingual children and gains were sustained at the delayed post-intervention assessment (end of Year 2). The same improvement was not detected for the Big Books intervention group. Comparisons revealed a 10 month reading age difference and 11 month spelling age difference between the two groups in favour of the Jolly Phonics group. However, follow-up assessment at the end of Key stage 1 (Year 2) did not reveal significant differences in children's reading comprehensionbetween the two groups, indicating that a phonics programme may not be enough to boost reading comprehension skills. Additionally, Conrad (2008) in a one week intervention study with Grade 2 typically developing children (mean age 7;07) aimed to find whether practising reading (using repeated reading) or spelling (by repeated spelling) would generalize to spelling or reading skill, respectively. Results revealed that training in spelling improved reading more than the opposite.

Interim summary

The above review shows that single case training studies can be employed as a means of informing models of cognitive processes, and also as a means of producing evidence for techniques that have positive clinical and educational outcomes. In the following sections investigations are reported of the possible causes of literacy difficulty in five children. The assessments used in Studies 1 and 3 tapping spelling, reading, PA, rapid naming, visual and verbal memory, non-verbal ability and global and partial letter report were used in order to explore the cause(s) of the spelling difficulty. On the basis of the pupils' difficulties, intervention was planned. A training targeting sublexical or lexical processes was conducted in each case. The first four training studies, presented next, directly addressed impaired spelling processes, while in the fifth training study with RF, a potential distal cause of the reading impairment was targeted.

The particpants in Study 4 were five school age children, LK, RI, ED, NT and RF. LK, RI and ED were seven years old, NT was ten years old and RF was twelve years old when assessment began. Participating children were monoliterate or biliterate in Greek and English. LK, RI, ED and NT were speakers of English and Greek and RF was monolingual in Greek. Although the children were receiving instruction in Greek and English neither of them was making progress in spelling and reading in either language. For LK, RI and NT the spelling intervention described below targeted both languages; whereas for ED only English spelling was targeted. A sublexical spelling intervention was administered for LK, RI and ED. The intervention was based on a study conducted by Brunsdon et al. (2002b), see previous section 7.1.4. on *Intervention studies*. It also used aspects of Stuart's (1999, 2004) research (the Jolly Phonics scheme was adopted) and Clay's (1993) reading recovery programme (the writing procedure was used). Finally, from Hatcher' (1994) Sound Linkage programme the phonological ability teaching procedure was used.

At the end of the sublexical intervention ED's spelling skill was not significantly improved, therefore a training targeting lexical spelling skills was administered next.

The same intervention was also used with NT who had characteristics of mixed dysgraphia and vocabulary difficulties. The intervention was based on previous training studies targeting lexical processes (such as those of Behrmann, 1987; De Partz et al., 1992; Weekes & Coltheart, 1996; Brunsdon et al., 2005). Particularly, De Partz et al. (1992) used a visual imagery technique in a study with a 24-year-old male, LP, who had acquired surface dysgraphia. The intervention targeted irregular words using drawings embedded in words. LP's performance improved significantly. Behrmann (1987) used a technique linking homophone pairs with pictorial representations in order to link orthography with semantics. Improvement was found for trained homophones and untrained irregular words but not for untrained homophones. Weekes and Coltheart (1996) using a pictorial mnemonic technique found improvement for treated but not untreated words. For a description of Brunsdon et al.'s (2005) study see previous section on *Intervention studies*.

It was aimed to see whether spelling interventions that have been found to be successful with monoliterate dysgraphic participants (Brunsdon et al., 2005; Brunsdon et al., 2002a, 2002b; Kohnen et al., 2008a, 2008b) would achieve the same results with polyglot children. In addition, the aim was to examine which type of training would be more effective for these polyglot children with spelling difficulties and whether the spelling intervention might result in improvement in reading as well as spelling, similarly with findings from other intervention case studies (Kohnen et al., 2008a&b; Brunsdon et al., 2005; Kohnen & Nickels, 2010). For LK, RI and NT who were biliterate, we investigated whether after the intervention targeting sublexical processes they would produce more phonologically appropriate errors in spelling in Greek than English, since this is the pattern that has been reported for children learning to read and spell in two alphabetic writing systems where one is more transparent than the other (c.f. Gupta & Jamal, 2007; Niolaki & Masterson, 2012; see also Studies 2 & 3).

Finally, a case study with a twelve year old boy, RF who was a monolingual speaker of Greek is reported. RF showed slow word reading and a difficulty in spelling irregular words but not nonwords. Assessments revealed that RF did not appear to have a phonological deficit; but indicated letter report difficulty. On the basis of previous work linking simultaneous multi-character processing and reading (e.g., Bosse et al., 2007, see Chapter 6) an intervention was devised which aimed at improving RF's ability to report letter arrays of increasing length, targeting this time a distal cause of the reading impairment and not directly the impaired reading processes as in other intervention studies (see for example Brunsdon et al., 2002(b)). The training study further investigated the significance of intervention studies for testing hypotheses regarding causal relationships among cognitive processes (Nickels et al., 2010) and the notion of specific profiles of developmental dyslexia/dysgraphia in both opaque and transparent orthographies (Castles & Coltheart, 1993; Manis et al., 1996; Stanovich et al., 1997; Cholewa et al., 2010; Douklias et al., 2009, see section 7.1.3).

The overarching aim was to examine whether any improvement as a result of the intervention might be accompanied by improvement in tasks considered to be associated with the route targeted (lexical or sublexical). If this was found to be the case then it would provide support for the hypothesis linking the intervention conducted and lexical or sublexical processing. Based on the above review the following research questions were examined:

Research questions:

- Are Greek-English biliterate pupils with reading and spelling difficulties impaired in both languages?
- Specifically, does the transparency of the Greek language mitigate spelling difficulty or does the opaqueness of the English language augment the impairment in both languages?
- Can subtypes of developmental dyslexia/dysgraphia (surface and phonological) be found among those students with impaired reading and spelling?
- Which could be the underling cognitive impairment\s associated with dyslexia/dysgraphia in multilingual and monolingual Greek and English children with literacy difficulties?
- Which type of intervention is effective in order to help the children mitigate their difficulty?

Case studies and the interventions conducted will be presented next. Investigations were based on DR models of reading and spelling (e.g., Coltheart, 1981; Barry, 1994, see section 2.3.1 for a review) since these have come to be used extensively for single case and case series intervention studies for literacy difficulties (e.g., Brunsdon et al., 2002; Brunsdon et al., 2005). Qualitative analysis of spelling errors is also reported. As for the group studies, misspellings were categorized as phonologically or non-phonologically appropriate in relation to the target word.

7.2 Case study: LK

Introduction

LK was a trilingual Greek-, English- and German-speaking boy aged 7;03 when the assessment began (in January 2010). LK's mother is Greek and his father is German and both languages are spoken at home. He was attending Grade 1 (the first year) of a Greek Independent school in London, UK. The school is located in a borough considered to be one of the most multilingual and multicultural in London (Wallace, 2008). In the Greek Independent school children receive instruction in Greek language arts (through the medium of Greek) for eight hours per week and English literacy (also through the medium of Greek) for ten hours per week. At the school, formal teaching of English and Greek start at the beginning of Grade 1 when children are 6 years old. Prior to this, children normally attend the Greek nursery, where the focus is on oral skills and some pre-literacy skills for both English and Greek. LK did not attend the Greek nursery. He had attended a local nursery prior to Grade 1 for two years that placed emphasis on physical education and learning through play. Formal teaching of English literacy was not included in their curriculum and at this point LK did not learn to read in English.

Table 38 gives the results of background assessments and reading and spelling for English and Greek (although LK was fluent in German he was not literate in this language and was not receiving any instruction in German). Assessment of LK's spelling in English revealed that he could not spell his name correctly (he wrote only the first two letters) and he was not able to spell any high frequency words apart from the word *at*. He was only able to write in English the letters for the sounds /m/, /a/, /g/, /t/ and /s/. He made frequent letter reversals. In Greek he was able to spell his name and surname but there was no clear discrimination between upper and lower case letters. He spelled just two high frequency words correctly (μαμά /mama/ (mother) and όχι /ohi/ (no)). Assessment of working memory, arithmetic and receptive vocabulary in both languages did not reveal low performance. For English reading and spelling, (based on the WIAT-II, Teacher's edition (Wechsler, 2006)) LK obtained a below average standardized score.

Standardised scores were not available for the Greek reading and spelling assessments and so LK's performance was contrasted with that of an age and non-verbal ability matched comparison group (*N*=6, mean age=7;04, *SD*=0;02). The comparison group consisted of bilingual Greek- and English-speaking children attending the same class at school as LK. All were reported to be exhibiting average levels of literacy ability by their class teacher. A modified *t*-test (Crawford & Howell, 1998) was used to compare LK's score with those of the comparison group (and for all the case studies presented in the thesis). This is a more robust statistical analyses when dealing with small samples. Significance was calculated using one-tailed tests (Crawford & Garthwaite, 2002). Scores for the comparison group are also given in the tables. LK's scores for spelling and reading were significantly different from those of the comparison group, $t(6)=4.7$, $p=.003$, $r=.88$ and $t(6)=60.8$, $p<.00001$, $r=.99$, respectively.

Table 38: *Standardized scores in background assessments for LK 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)*

	LK	Comparison group mean
	English measures	
Non-Verbal Reasoning[α]	96	105 (23)
Arithmetic[β]	100	
Working memory[c]	95	
Spelling[d]	63	
Reading accuracy[d]	52	
Receptive Vocabulary[e]	106	
	Greek measures	
Spelling[f]	**0****	**31.9 (6.3)**
Reading accuracy[f]	**0*****	**98.6 (1.5)**
Receptive Vocabulary[g] (max=174)	**66.6**	**43 (26.7)**

Note: [α]Matrix Analogies Test, Naglieri (1985), [β] WISC-IV, arithmetic subtest (Wechsler, 2003), [c]WISC-IV, digit span subtest (ibid.),[d]WIAT-II, Teacher's edition (Wechsler, 2006), [e] BPVS II (Dunn et al., 1997), using norms for EAL, [f]test developed by Mouzaki, et al., (2007), [g]PPVT-adapted for Greek (Simos et al., 2011), $^{**}p<.01$, $^{***}p<.001$

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, and RAN. Results of the assessments are reported in Tables 39 and 40.

Spelling and reading of irregular and nonwords

In order to investigate LK's spelling in more detail, his performance in irregular word and nonword spelling (tasks targeting lexical and sublexical spelling processes) was examined. The word and nonword stimuli were taken from the study of Loizidou-Ieridou et al. (2009), who had selected the items to investigate spelling development in Greek-speaking children. There were 20 irregular words and 40 nonwords. Half the items in each set were short (two to three syllables) and half were long (four to five syllables). Irregular words were those in which the vowel should be spelled with a grapheme that deviated from the predominant phoneme-grapheme correspondence. Half the irregular words were low frequency (mean=0.38, *SD*=0.35) and half were high frequency (mean=32.54, *SD*=64.50) according to values from the Greek frequency database (GREEKLEX, Ktori, van Heuven, & Pitchford, 2008). The nonwords and irregular words were presented for spelling to dictation in blocks, with non-words presented first as nonword spelling is less demanding in comparison to regular and irregular words. Each irregular word was read aloud by the tester and then provided in the context of a sentence for disambiguation. He was not able to spell or read any of the items. Table 39 presents accuracy scores in spelling and reading of irregular and nonwords for LK and the same age control children. Modified *t*-tests conducted indicated that his performance was significantly lower in all submeasures of reading and spelling in comparison to the same age comparison group's performance. Particularly, $t_{English\ irregular\ spelling}(6)=2.7$, $p<.05$, $r=0.74$, $t_{English\ nonword\ spelling}(6)=3.8$, $p<.01$, $r=0.7$, $t_{English\ irregular\ reading}(6)=2.3$, $p<.05$, $r=0.68$, $t_{English\ nonword\ reading}(6)=3.1$, $p<.01$, $r=0.74$, $t_{Greek\ irregular\ spelling}(6)=4.2$, $p<.01$, $r=0.78$, $t_{Greek\ nonword\ spelling}(6)=10.1$, $p<.0001$, $r=0.97$ and $t_{Greek\ nonword\ reading}(6)=45.5$, $p<.0001$, $r=0.99$.

Table 39: *Percentage correct for LK and the comparison group in spelling and reading irregular words and nonwords (standard deviations are in parentheses)*

	LK	*Z*	Comparison group mean
	English measures		
Irregular words spelling$^{\alpha}$(max. 30)	0*	-1.6	56 (18.7)
Nonwords spelling$^{\alpha}$(max. 30)	0**	-1.5	71 (17.1)
Irregular words reading$^{\alpha}$(max. 30)	0*	-1.6	57.2 (22.7)
Nonwords readinging$^{\alpha}$(max. 30)	0**	-1.8	71.6 (21.2)
	Greek measures		
Irregular words spelling$^{\beta}$(max. 20)	0**	-1.7	45 (9.9)
Nonword spelling$^{\beta}$(max. 40)	0****	-1.4	89 (8.2)
Nonword reading$^{\beta}$ (max. 40)	0****	-2.2	98.3 (2.0)

Note: $^{\alpha}$DTWRP (Forum for Research in Language and Literacy, 2012), $^{\beta}$List of irregular[2] words and nonwords from Loizidou et al. (2009), *p<.05, ** p<.01, **** p<.0001

Phonological ability (PA)

PA was assessed with the blending subtask of the Comprehensive Test of Phonological Processing (CTOPP, Wagner et al., 1999). LK's performance was age appropriate, but when he was assessed on a phoneme segmentation task and a phoneme deletion task from Hatcher’s (1994) pre-intervention screening battery his scores were 0 out of 6 correct (standardized score of 36) and 1 out of 6 (standardized score of 85), respectively. Phonological ability in Greek was assessed with the blending subtest from the Athena Test (Paraskevopoulos et al., 1999). LK obtained a standardized score of 70. Additionally LK was unable to score in the spoonerisms task (from the PhAB, Frederikson et al., 1997) either in English or in Greek, $t(6)=3.5$, $p<.01$, $r=.81$ and $t(6)=3.4$, $p<.01$, $r=.81$, respectively.

Rapid Automatised Naming

Assessment in RAN pictures and digits, (PhAB, Frederikson et al., 1997) revealed no significant difference from the scores of the comparison group.

Visual memory

Assessment of LK’s visual memory using the memory for pictures and designs subtasks from the Athena Test (Paraskevopoulos et al., 1999) revealed a significant difference for memory for abstract designs, $t(6)=2.1$, $p<.05$, $r=.65$, but not for pictures compared with the comparison group's scores. Further assessment of visual memory was carried out using simultaneous and sequential visual memory tasks.

The simultaneous visual memory task was adapted from the one described by Hulme (1981). The current task used Arabic characters. Arrays of 2, 3 or 4 characters were presented on the screen of a DELL Inspiron computer for 10 seconds each. A test 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 test array contained the characters in a different order and intermixed with two new characters. LK was asked to report the characters, in correct order, by pointing on the screen. There were three practice trials.

The sequential visual memory task employed characters from Tamil and Devanagari and 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 test array was then presented following a retention interval of 1 second for the first six trials and 10 seconds for the following six trials. LK was asked to select the characters in the correct order from a test array of characters intermixed with two distractor characters.

For both tasks items had to be recalled in the correct order for the 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. LK's performance did not significantly differ from that of the same age comparison group in memory for simultaneously presented characters but it was significantly worse for memory for sequentially presented characters, $t(6)=2.9$, $p<.05$, $r=.76$.

Summary of assessments

LK seemed to have impairments in phonological ability in both languages as indicated by the phoneme segmentation and spoonerisms task in English and the blending and spoonerisms task in Greek. There were also indications of deficits in visual memory for abstract designs and for characters presented sequentially. This is in agreement with findings presented by Seymour (1984), Goulandris and Snowling (1991) and Romani et al. (1999), see sections 2.4.1 and 3.2 for a review. LK did not exhibit a RAN deficit.

Table 40: *Phonological ability, RAN and visual memory scores of LK and the comparison groups. Scores in bold are for assessments where standardized scores were not available (standard deviations are in parentheses)*

	LK	*Z*	Comparison group mean
		English measures	
Blending[α] (max=20)	95	-.93	114 (20)
Spoonerisms[β] (max=20)	**0****	**-1.9**	**14 (3.7)**
RAN pictures[c] (in secs)	**65**	**.53**	**59.2 (9.2)**
RAN digits[c](in secs)	**46**	**.56**	**36.3 (16)**
		Greek measures	
Blending[d](max = 32)	70*	-1.6	119 (18)
Spoonerisms[e](max= 20)	**0****	**-1.9**	**14.3 (3.8)**
RAN pictures[f](in secs)	**66**	**-.39**	**66.8 (16)**
RAN digits[f](in secs)	**47**	**-.04**	**59.8 (29)**
Visual memory for pictures[g] (max=32)	**11**	**-.65**	**14 (4.1)**
Visual memory for designs[g](max=32)	**5***	**-1.5**	**14.3 (4.2)**
Visual memory simultaneous[h] (max=12)	**5**	**-1.6**	**5.8 (1.3)**
Visual memory sequential[i] (max=12)	**3***	**-.55**	**7.2 (1.3)**

Note: [α]CTOPP; Wagner et al. (1999), [β]PhAB; Frederickson et al. (1997), [c]Rapid Automatized Naming, PhAB; (ibid.), [d]Athena Test; Paraskevopoulos et al. (1999), [e]Spoonerisms task devised for Greek, adapted from PhAB; (ibid.), [f]Rapid Automatized Namimg, adapted from PhAB;(ibid.), [g]Athena Test; Paraskevopoulos et al. (1999), [h]adapted from Hulme (1981), [i]adapted from Goulandris and Snowling 1991, **p*<.05, ** *p*<.01

Rationale for training

It was decided to provide a training that aimed at improving LK's spelling skills, since improvement in spelling as a result of training has been found to generalize to reading skill (Brunsdon et al., 2005; Kohnen et al., 2008a; Ouellette, 2010; Conrad, 2008, also see section 3.2. and Introduction in Study 4) while the opposite has not been found to be the case (Perfetti, 1997). Additionally, spelling is a harder task than reading for both Greek and English orthographies. LK was towards the end of Grade 1 (in spring term- January to April) and he was not able to produce any writing, while children at this stage are typically able to write familiar and unfamiliar words to dictation and recognise the Greek letter-sounds. In English they are typically able to spell a pool of high frequency irregular words and they have been taught the letter sounds and names. Thus LK's teachers were concerned about his ability to cope in Grade 2. Consequently, it was considered important to put in place trainning that would target spelling. LK's sublexical skill was virtually non-existent in both languages, therefore it was decided that support for his letter-sound awareness and his decoding skills for spelling would be provided. Sublexical processes were chosen as the target since LK 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 2. A description of the sublexical spelling training programme is included in the next section. The programme began in February 2010 and lasted for nine weeks.

Sublexical Training programme

Sessions took place at LK's school, where the researcher saw him/her individually for one hour per week. 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 adopted was the same for each session and a letter outlining what LK should do at home was given every week to his parents.

Procedure

The training lasted for nine weeks and included explicit teaching of phonics, following Hatcher's (1994) programme, it also used the Jolly Phonics materials (Lloyd, Wernham, & Jolly, 1992) and 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 Brunsdon et al. trained reading whereas spelling was targeted in the present study. Sessions began with assessment of letters taught the previous week (apart from the first session). Each week six letters or digraphs were taught following the order of the Jolly Phonics scheme. Each letter was related to a word that LK sounded out and wrote, based on the procedure of Brunsdon et al. (2002). For example, if the target letter was *U* LK was presented with the letter written on a card and was asked to look at a card with a word beginning with that letter written on it (e.g., <*up*>). LK was asked to read and repeat the word three times, following the tester. Then he was asked to copy the letter, upper and lower case, and 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/digraph.

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 included working on conceptualizing words as part of sentences, syllabic awareness, phoneme blending, phoneme discrimination and identification and transposition of phonemes. The activities are outlined in Table 41.

Table 41: *Programme of phonological activities (from Hatcher, 1994)*

Session	Activity
Week 1	Conceptualization of words as parts of the sentence
Week 2	Syllabic awareness
Week 3	Phoneme blending
Week 4	Rhyme
Week 5	Phoneme discrimination and identification
Week 6	Phoneme segmentation
Week 7	Deletion of phonemes
Week 8	Substitution of phonemes
Week 9	Transposition of phonemes

Following the phonological activity in each session, LK 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), LK 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, 1973). The author devised phonological activities in Greek equivalent to the ones just described.

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

1) Show a card with a letter on it to …..

2) For each card … should say <u>the sound</u> 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 letter

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

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

This procedure had to be followed every day, and the parents were asked to practice all six letters/digraphs in the same way.

Post-training assessment

Post-training assessments were conducted one week and then four months after the end of the training in order to look for gains in spelling performance, and whether these were sustained over time. The tests that had been used prior to training for spelling, reading and phonological ability were employed. Results are given in Table 42 and indicate that LK showed improvement in spelling and reading for both English and Greek. He also showed improvement in phonological ability for Greek. In order to investigate whether effects of the training were specific to literacy and phonological processes, the arithmetic subtest from WISC-IV was also re-administered immediately after the training. Arithmetic scores showed no change (pre-training standard score = 100, post-training standard score = 100).

Table 42: *Pre-training, immediate and delayed post-training results for LK and comparison group performance (scores in bold are for assessments where standardized scores were not available and represent percentage correct, standard deviations are in parentheses)*

	Pre-training	Immediate post-training	Delayed post-training	Comparison group mean
English measures				
Spelling$^{\alpha}$	63	79	87	
Reading accuracy$^{\alpha}$	52	75	79	
Phonological ability$^{\beta}$	95	125	100	
Greek measures				
Spelling^{c}	**0**	**17**	**36.6**	**31.9 (6.3)**
Reading accuracy^{c}	**0**	**92**	**98.3**	**98.6 (1.6)**
Phonological ability^{d}	70	95	125	119 (18)

Note: $^{\alpha}$WIAT-II, Teacher's edition (Wechsler, 2006), $^{\beta}$blending subtest from CTOPP: Wagner et al. (1999), ^{c}test developed by Mouzaki et al. (2007), ^{d}blending subtest from the Athena Test (Paraskevopoulos et al., 1999).

Detailed investigation of spelling processes

When the intervention was concluded LK's performance in irregular word and nonword spelling (tasks targeting lexical and sublexical spelling processes, respectively) was examined. Before the training LK had not been able to spell any of the irregular words and nonwords. Table 43 presents his results following the training. The assessment was also administered to a group of age matched bilingual English- and Greek-speaking children (*N*=9) from LK's class at school. The comparison group had an average chronological age of 7;05 (*SD*=0;03) years. The comparison children were tested at the same time as LK, that is, when he finished the training (immediate post-training assessment, Time 1 (T1)) and then four months later (delayed post-training assessment, Time 2 (T2)). For the comprison group related t-tests conducted did not reveal significant differences between T1 and T2 assessments ($p>.05$). The results revealed that LK's sublexical skills, as reflected in nonword spelling, were better than lexical processes for both English and Greek. An advantage for nonword spelling relative to irregular word spelling was also found for both languages in the comparison group[6]. For English spelling, McNemar tests conducted did not reveal a significant difference between pre-intervention exception word spelling and T1 performance, or between T1 and T2. However, for nonword spelling the difference between pre-intervention and T1 approached significance ($p=0.06$). The difference between T1 and T2 nonword scores was not significant. For Greek, there was not a significant difference for irregular word spelling between pre-intervention and T1 and between T1 and T2 assessments. For nonword spelling the difference was significant between pre-intervention-T1 but not between T1-T2. Results for both languages indicate an improvement in nonword spelling as a result of intervention.

[6] The Loizidou et al. and DTWRP items are not matched on variables such as printed word frequency, word length etc., so direct comparison of levels of accuracy is problematic.

Table 43: *Percentage correct for LK and the comparison group in spelling irregular words and nonwords (standard deviations are in parentheses)*

	LK			Comparison group	
	Pre-training *Z*s	Immediate post-training	Delayed post-training	*Time 1*	*Time 2*
			English measures		
Irregular words[α](max. 30)	-1.6	0	3.3	56 (18.7)	63 (15)
Nonwords[α](max. 30)	-1.5	17	30	71 (17.1)	81 (7.1)
			Greek measures		
Irregular words[β](max. 20)	-1.7	5	15	45 (9.9)	49 (12)
Nonwords[β](max. 40)	-1.4	38	53	89 (8.2)	90 (7.1)

Note:[α]DTWRP (FRLL, 2012), [β]List of irregular words and nonwords from Loizidou et al. (2009)

Qualitative analysis of spelling errors

In Study 2 using the same stimuli, and with children of similar age to LK, it was reported that monolingual English speaking children made 67% phonologically appropriate errors and monolingual Greek speaking children made 94% of such errors. Qualitative analysis of the spelling errors made by LK was carried out. Inspection of the types of errors made in irregular word spelling at delayed-post intervention assessment revealed that the majority were phonologically appropriate (60% for English and 88% for Greek, for example, *monkey*> MANKI *ζητιανεύω*> ZITHANEBO /zitjanevo/ <beg>).

Discussion

LK is a trilingual boy who showed severe difficulties in reading and spelling. Following training that targeted sublexical spelling processes spelling showed improvement. This is in line with the training study carried out by Brunsdon et al. (2002), using similar techniques with a monolingual child with mixed dyslexia. LK's reading also showed improvement, in line with the findings of other studies targeting spelling (Kohnen et al., 2008a, Brunsdon et al., 2005). Assessment of LK's phonological skills revealed significant improvement in Greek, and this is likely due to the inclusion of this component in the training. Examination of performance in spelling irregular words and nonwords following the intervention showed an advantage for sublexical spelling processes. The lower level of attainment in irregular word spelling is likely due to the inconsistent nature of English and Greek for spelling. It is likely that explicit teaching of whole word spellings, and many encounters with correct spellings are required to develop lexical skills (Bosman & van Orden, 1997; van Hell et al., 2003, see section 2.3.2.3). LK also showed a significant deficit in visual memory for abstract designs, which based on Seymour (1984), could relate to spelling problems, and impairment in visual memory for sequentially presented items as in the case study of Romani et al. (1999) (see sections 2.4.1. & 3.2.). However, LK also appeared to have a phonological deficit which was not exhibited by participants of the aforementioned studies.

Qualitative analysis of spelling errors revealed that following the intervention LK made more phonologically appropriate errors in Greek than in English. This is in agreement with other cross-linguistic studies of children learning English and another alphabetic but more transparent writing system. These studies have been conducted with both typically developing children (e.g., Studies 1 & 2 of the current thesis) and those with reading and spelling difficulties (e.g., Gupta & Jamal, 2007; Hanley et al., 2004, discussed in section 7.1.2.). Next, a sublexical training study with a trilingual boy will be presented.

7.3. Case study: RI

Introduction

RI was aged 7;04 when first assessed. He is an emergent trilingual, but he was literate only in English and Greek, although he also knew some words in Portuguese, according to his parents. He attended a Greek medium school in London (for a description of the school setting see previous case) and discussion with his Greek and English teachers revealed that RI was poor in reading and spelling in both languages although he was already attending Grade 2 (Year 3 in English) in the Greek school. Children of this age in Greek are able to decode accurately almost all Greek real and nonsense words, spell to dictation many high frequency words and start to realize the consistency of inflectional spelling. In English they are typically able to spell a pool of high frequency irregular words and they have been taught the letter sounds and names. RI, unlike LK, attended nursery at the Greek medium school.

His parents reported that from the time that RI was under two years-old he had suffered frequent ear infections and that this affected his hearing ability. He was also operated upon and grommets were inserted in his ears. Shaphiro et al., (2009) reported that children with early otitis media episodes (0-24 months) had significantly lower scores in reading and phonological ability in comparison to control children and children with late otitis media episodes. Additionally, RI had difficulty in pronouncing the /l/ sound and when he was 5 years old he attended speech therapy for 6 months.

Table 44 gives the results of reading and spelling assessments for English and Greek. Assessment of RI's spelling in English revealed that he could spell some high frequency words (e.g., *we, is, big, look*). He recognized single letters accurately, but he could not apply phoneme-to-grapheme rules when the graphemes consisted of two letters (e.g., er, ur, ir etc.). His spelling errors in the WIAT-II teachers edition spelling subtest (Weshler, 2005) were phonologically inappropriate in 80% of occasions (e.g., *candy*-> CADE, *right*-> RADE, *jumped*-> JPING). He also made some letter reversals. In Greek he was able to recognize simple graphemes and write high frequency words (such as, από (/apo/ from), έλα (/ela/ come, και (/ke/ end), είναι (/ine/ is)), however in consonant clusters he frequently omitted letters. RI made non-phonologically appropriate errors in the Greek spelling test of Mouzaki et al. (2007) on 77% of occasions (e.g., *τραπέζι* (/trapezi/, table)-> ΤΑΠΕΖΙ /tapezi/, *χρήματα* (/xrimata/ money) -> ΧΙΜΑΤΑ /himata/). RI was asked to spell the 60 word list of Masterson et al. (2008)

and he made 87% non-phonologically appropriate errors in English and 66% in Greek. Assessment of working memory, arithmetic and receptive vocabulary in both languages did not reveal low performance.

RI's performance was contrasted with that of an age and non-verbal ability matched comparison group (N=7, mean age=7;05, SD=0;03). The comparison group consisted of bilingual Greek- and English-speaking children attending the same class at school as RI. All were reported to be exhibiting average levels of literacy ability by their class teacher. For Greek spelling and reading RI's performance was significantly lower than that of the comparison group, $t(7)=2.3$, $p<.05$, $r=.66$ and $t(7)=44.9$, $p<.0001$, $r=.99$, respectively.

Table 44: *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	104 (20)
Arithmetic[β]	95	
Working memory[c]	90	
English measures		
Reading Comprehension[d]	103	
Spelling[d]	82	
Reading accuracy[d]	74	
Reading speed[d]	79	
Receptive Vocabulary[e]	114	
Greek measures		
Spelling[f]	**10***	**30 (8.1)**
Reading accuracy[f]	**27*****	**99 (1.5)**
Receptive Vocabulary[g] (max=174)	**34**	**38.3 (27)**

Note: [α]Matrix Analogies Test, Naglieri (1985), [β] WISC-IV, arithmetic subtest (Wechsler, 2003), [c]WISC-IV, digit span subtest (ibid.), [d]WIAT-II, Teacher's edition (Wechsler, 2006), [e] BPVS II (Dunn et al., 1997), using norms for EAL, [f]test developed by Mouzaki et al. (2007), [g]PPVT-adapted for Greek (Simos et al., 2011), *p<.05, ***p<.001

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 global and partial letter report. The results are reported in Table 45. The assessments were the same as the ones used for LK with the exception of letter report. The procedure for the letter report tasks is described in Study 3.

Spelling of irregular and nonwords

Unlike LK, RI was able to spell and read irregular words and nonwords in English and also spell the same category of words in Greek. RI exhibited difficulty in both lexical and sublexical processes as he scored lower than the comparison group in both irregular and nonword reading and spelling, $t_{English\ irregular\ spelling}(9)=2.8$, $p<.05$, $r=.68.$, $t_{English\ nonword\ spelling}(9)=3.38$, $p<.01$, $r=.74$, $t_{English\ irregular\ reading}(9)=2.02$, $p<.05$, $r=.55$, $t_{English\ nonwprd\ reading}(9)=3.5$, $p<.01$, $r=.76$, $t_{Greek\ irregular\ spelling}$ $(9)=3.8$, $p<.01$, $r=.78$, $t_{Greek\ nonword\ spelling}(9)=7.9$, $p<.0001$, $r=.93$ and $t_{Greek\ nonword\ reading}(9)=3.6$, $p<.01$, $r=.77$. Table 45 gives the results of irregular and nonword reading and spelling assessments for English and Greek.

Table 45: *Percentage correct for RI and the comparison group in spelling and reading irregular words and nonwords (standard deviations are in parentheses)*

	Pre-training	*Z*	Comparison group mean
	English measures		
Irregular word spelling$^{\alpha}$	0*	-1.9	56 (18.7)
Nonword spelling$^{\alpha}$	10**	-1.5	71 (17.1)
Irregular word reading$^{\alpha}$	16.6*	-1.4	57 (19)
Nonwords reading$^{\alpha}$	3.3**	-1.9	70 (18)
	Greek measures		
Irregular word spelling$^{\beta}$	5**	-1.7	45 (9.9)
Nonword spelling$^{\beta}$	20****	-1.4	89 (8.2)
Nonword reading$^{\beta}$	25**	-2.4	91 (17)

Note: $^{\alpha}$DTWRP (Forum for Research in Language and Literacy, 2012), $^{\beta}$List of irregular[2] words and nonwords from Loizidou et al. (2009), *p<.05, ** p<.01, **** p<.0001

Phonological ability

RI's performance in both Greek and English was weaker than that of the comparison group, although the difference was only significant for Greek. Assessment in phoneme segmentation and deletion tasks from Hatcher's (1994) pre-intervention screening battery indicated that his performance was low average (for both tasks; he gained standardized scores of 85). Phonological ability in Greek revealed a standardized score of 79. Additionally RI scored significantly lower than the comparison group in spoonerisms tasks in both languages, $t_{English}(7)=2.8$, $p<.05$, $r=.72$ and $t_{Greek}(7)=3.6$, $p<.01$, $r=.80$.

Rapid Automatized Naming

RI's performance in rapid automatized naming of digits and pictures did not indicate any deficit.

Visual memory

Assessment of RI's visual memory did not show impairment apart from his performance in visual memory for sequentially presented items. RI's visual memory score for abstract designs in the Athena subtest was slightly higher than that of the comparison group. However, RI's lower performance in sequentially presented characters in visual memory task, $t(7)=2.2$, $p<.05$, $r=.63$ agrees with Romani et al.'s (1999) single case study and with LK's performance. In contrast to RI, LK also had low performance in visual memory for abstract designs.

Global and partial letter report

RI's performance in letter report in both languages did not significantly differ from that of the comparison group.

Summary of assessments

RI's ability to spell and read both irregular words and nonwords was impaired in both languages. Further assessments indicated that RI had a phonological deficit in both languages in which he was literate. There were also indications of accompanying deficits in visual memory for characters presented sequentially but not of a general short-term visual memory deficit in agreement with Romani et al.'s (ibid) case report. RI did not exhibit a RAN or a letter report deficit.

Table 46: *Phonological ability, RAN, visual memory and letter report 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	*Z*	Comparison group mean
	English measures		
Blending[α] (max=20)	100	-.90	114 (18)
Spoonerisms[β] (max=20)	**4***	**-1.7**	**15 (3.7)**
RAN pictures[c] (in secs)	**60**	**-.06**	**61 (9.2)**
RAN digits[c] (in secs)	**33**	**-0.6**	**34 (14)**
Global report arrays correct[d] (max=20)	**3**	**-.24**	**4.2 (4.3)**
Global report letters correct[d] (max=100)	**73**	**.36**	**68 (13)**
Partial report[d] (max=50)	**42**	**.71**	**37 (6.1)**
	Greek measures		
Blending[e] (max = 32)	79*	**-1.6**	121 (17)
Spoonerisms [f](max= 20)	**0****	**-2.0**	**15 (3.9)**
RAN pictures [g](in secs)	**70**	**.01**	**70 (16)**
RAN digits[g] (in secs)	**45**	**1.0**	**36 (6.7)**
Global report arrays correct[d] (max=20)	**0**	**-.35**	**.29 (0.76)**
Global report letters correct[d] (max=100)	**55**	**.47**	**48.4 (13)**
Partial report[d] (max=50)	**29**	**-.73**	**32 (2.8)**
Visual memory for pictures[h] (max=32)	**16**	**.20**	**15 (4.6)**
Visual memory for designs[h] (max=32)	**20**	**1.2**	**14.4 (3.8)**
Visual memory simultaneous[i] (max=12)	**7**	**.70**	**6 (1.2)**
Visual memory sequential[j] (max=12)	**3***	**-1.4**	**7 (1.7)**

Note: [α]CTOPP; Wagner et al. (1999), [β]PhAB; Frederickson et al. (1997), [c]Rapid Automatized Naming, PhAB; (ibid.), [d]Letter report tasks, adaptation from Bosse et al. (2007), [e]Athena Test; Paraskevopoulos et al. (1999), [f]Spoonerism task devised for Greek, adapted from PhAB; (ibid.), [g]Rapid Automatized Namimg, adapted from PhAB;(ibid.), [h]Athena Test; Paraskevopoulos et al. (1999), [i]adapted from Hulme (1981), [j]adapted from Goulandris and Snowling 1991, **p*<.05, ** *p*<.01

Rationale for training

It was decided to provide a training that aimed at improving RI’s spelling skills, in order to see whether improvement in spelling as a result of training would be found to generalize to reading skill as was found to be the case for LK and in other case study reports (Brunsdon et al., 2005; Kohnen et al., 2008a; Ouellette, 2010; Conrad, 2008). RI was in the spring term of Grade 2 and he was not able to spell, while Greek children at this stage are typically able to write short passages using a large number of sight words that they can use accurately. In English, they are at a similar level, employing orthographic and morphological rules. Thus RI’s teachers and parents were concerned about his ability to cope in Grade 3. Consequently, it was considered important to put in place training that would target spelling. RI’s sublexical skill was significantly weak, therefore it was decided that support for his letter-sound awareness and his decoding skills for spelling would be provided. Sublexical processes were chosen as the target since he 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.

Training programme

The procedure and duration of the training were exactly the same as those for LK and described earlier. The main difference between the two programmes was that only letter combinations and not single graphemes were taught following the order of the Jolly Phonics scheme for English, and a similar order of letter combinations for Greek was devised by the author[7].

Post-training assessment

Post-training assessments were conducted one week and then four months after the end of the training (immediate and delayed post-intervention respectively) in order to look for gains in performance, and whether these were sustained over time. The tests that had been used prior to training for reading, spelling and phonological ability were employed. Results are given in Table 47 and indicate that RI showed moderate improvement in spelling for Greek. He also showed improvement in reading and

[7]The letter combinations RI was 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: 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/.

phonological ability for Greek. Unlike LK, RI's English reading in the standardized assessment did not improve.

Table 47: *Pre-training, immediate and delayed post-training results for RI and comparison group performance (scores in bold are for assessments where standardized scores were not available and represent percentage correct, standard deviations are in parentheses)*

	Pre-Intervention	Immediate Post-intervention	Delayed Post-Intervention	Comparison group mean
		English measures		
Spelling[α]	82	82	85	
Reading accuracy[α]	74	77	74	
Phonological ability[β]	100	100	100	
		Greek measures		
Spelling[c]	**10***	**17**	**25**	**30 (8.1)**
Reading accuracy[c]	**27*****	**32*****	**45*****	**99 (1.5)**
Phonological ability[d]	79*	95	104	121 (17)

Note: [α]WIAT-II, Teacher's edition (Wechsler, 2006), [β]blending subtest from CTOPP: Wagner et al. (1999), [c]test developed by Mouzaki et al. (2007), [d]blending subtest from the Athena Test (Paraskevopoulos et al., 1999), *p<.05, ***p<.001

When the intervention was concluded RI's performance in irregular word and nonword spelling was examined. Table 48 presents the results prior to and following training. The assessment was conducted with a group of bilingual English- and Greek-speaking children from RI's school who served as a comparison group (*N*=9, mean age 7;05, *SD*=0;03)). Analysis with McNemars test indicated for English irregular word and non-word spelling no significant difference between pre-intervention–T1 and between T1 and T2. For English reading for irregular words a marginally significant improvement was detected between pre-intervention and T2 (*p*=.06). However, for English nonword reading the difference between pre-intervention and T2 was significant (*p*=.01). This indicates that although for English irregular word and nonword reading improvement was observed, this was not the case for spelling. For Greek spelling of irregular words, no significant difference was found. However, for nonword spelling and reading a significant improvement was detected between pre-intervention and T2 performance (*p*=.001 & *p*=.0001, respectively).

Table 48: *Percentage correct for RI and the comparison group in spelling and reading irregular words and nonwords (standard deviations are in parentheses)*

	Pre-training	*Z*	Post-training		Comparison group	
			Immediate	Delayed	*Time 1*	*Time 2*
			English measures			
Irregular word spelling$^{\alpha}$	0	-1.9	13	17	56 (18.7)	63 (15.3)
Nonword spelling$^{\alpha}$	10	-1.5	10	20	71 (17.1)	81 (7.1)
Irregular word reading$^{\alpha}$	16.6	-1.4	50	33.3	57 (19)	-
Nonwords reading$^{\alpha}$	3.3	-1.9	7	30	70 (18)	-
			Greek measures			
Irregular word spelling$^{\beta}$	5	-1.7	5	5	45 (9.9)	49 (12)
Nonword spelling$^{\beta}$	20	-1.4	63	48	89 (8.2)	90 (7.1)
Nonword reading$^{\beta}$	25	-2.4	38	58	91 (17)	-

Note: $^{\alpha}$DTWRP (Forum for Research in Language and Literacy, 2012), $^{\beta}$List of irregular[2] words and nonwords from Loizidou et al. (2009)

Finally, in order to investigate whether any effects of the training were specific to literacy processes the arithmetic subtest from WISC-IV was re-administered immediately after the training. Scores showed no change (pre-training standard score = 95 and post-training standard score = 95).

Discussion

RI is an emergent trilingual boy who showed severe difficulties in reading and spelling. Following training that targeted sublexical spelling processes his spelling for English did not show improvement in a standardised assessment, whereas improvement was observed in Greek spelling and reading. Examination of lexical and sublexical spelling processes showed an improvement in nonword spelling for Greek but not for English. Improvement was observed for nonword reading in both languages. Improvement in reading, although intervention targeted spelling, is in agreement with Brunsdon et al. (2005) and Kohnen et al. (2008a), also see Introduction Chapter 7. Like LK, RI's phonological skills showed significant improvement in Greek, and this is likely to have been due to the inclusion of this component in the training. RI showed a significant deficit in visual memory for sequentially presented characters, which according to Romani et al. (1999) see also section 3.2, could be detrimental for encoding serial order, a skill significant for accurate spelling.

In the next case study, a sublexical and lexical training study with a bilingual girl will be presented.

7.4. Case study: ED

Introduction

ED is a bilingual girl who was aged 7;09 when she was administered the background assessments. During the training only the one language in which she was literate, English, was targeted because her parents decided that improvement in English spelling skill was paramount. ED's mother tongue is Greek, but she was not literate in this language although she attended a Greek afternoon school (five hours per week) and was in Grade 1 when the assessment began. In the daytime ED, attended a mainstream English school and was in Year 2. The author was approached by ED's Greek literacy teacher who had concerns as ED was not showing any progress in Greek reading and spelling.

The results of background assessments and of reading and spelling are given in Table 49. Inspection of the table reveals that ED scored at an average level in nonverbal reasoning. Receptive vocabulary and phonological working memory were low average. Reading comprehension was at an average level. However, reading accuracy and spelling appeared to be impaired.

ED's scores on the non-standardised assessments were compared with those of a comparison group (*N*=7) matched to ED for age and nonverbal reasoning ability (mean age=7;06, *SD*=0;04 in years). Children in the comparison group attended the same class in the afternoon Greek school as ED and they were all bilingual in English and Greek.

Table 49: *Standardised scores in background assessments for ED and a comparison group (standard deviations are in parentheses)*

	ED	Comparison group mean
Non-Verbal Reasoning[α]	103	109.8 (16)
Arithmetic[β]	80	
Verbal Working memory[c]	80	
Reading comprehension[d]	110	
Spelling[d]	74	
Reading accuracy[d]	72	
Receptive Vocabulary[e]	90	

Note: [α]Matrix Analogies Test, Naglieri (1985), [β] WISC-IV, arithmetic subtest (Wechsler, 2003), [c]WISC-IV, digit span subtest (ibid.), [d]WIAT-II, Teacher's edition (Wechsler, 2006), [e] BPVS II (Dunn et al., 1997), using norms for EAL

Assessment of ED's spelling revealed that her spelling errors were mainly non-phonologically appropriate, for example, she spelt *look* > LKII, *candy* > CAD and *under* >UND. She was able to spell three high frequency words *up*, *sun* and *went*. ED's knowledge of phoneme-grapheme correspondences was better than LK's. ED frequently confused <a> with <e> and she did not know the split digraph rule. ED usually accurately spelled first and last consonants (for example, *half* - HUF, *street* - SET). ED's errors mainly involved vowel graphemes and she frequently omitted letters from clusters and the grapheme <R> (for example, *street* > SET, *dragon* > DIN, *corner* > CON).

Detailed assessment

ED was administered the same tasks as the ones used for LK and RI in order to investigate lexical and sublexical reading and spelling processes, and to assess for possible deficits of PA, visual memory, rapid naming and letter report. The results are presented in Table 50.

Spelling of irregular and nonwords

ED's performance in irregular word and nonword spelling was examined. Assessments revealed that her difficulty was manifested in reading and spelling of irregular words, *t*(8)=3.4, *p*<.01, *r*=.76 and *t*(8)=1.7, *p*=.06, *r*=.51, respectively, as well as nonwords *t*(8)=1.8, *p*=.05, *r*=.53 and *t*(8)=2.2, *p*=.05, *r*=.61, respectively.

Phonological ability (PA)

ED's performance in the blending subtask from the CTOPP was age appropriate; however, when compared with a same age comparison group, (*N*=7) matched to ED for age and nonverbal reasoning ability (mean age=7;06, *SD*=0;04 in years) her performance was significantly lower. Further assessment of PA with Hatcher's (1994) pre-intervention screening battery revealed that phoneme segmentation appeared to be unimpaired (standardised score=106), but phoneme deletion was in the low average range (standardised score=85). Additionally, ED was unable to score in the spoonerisms task from the PhAB, *t*(7)=2.1, *p*=.05, *r*=.62.

Rapid Automatized Naming

Assessment in RAN, pictures and digits, unlike LK and RI, revealed a significant difference in comparison to the same age comparison group. ED scored significantly lower than the comparison group, *t*(7)=5.4, *p*<.001, *r*=.89 and *t*(7)=7.03, *p*<.01, *r*=.92, respectively.

Visual memory

Assessment of ED's memory for pictures and designs revealed a significant difference only for visual memory for pictures, *t*(7)=2.9, *p*<.01, *r*=.62, and not for abstract designs compared with the scores of the comparison group. This finding is different from that of LK and RI, who did not exhibit poor performance in memory for pictures. Assessment of memory for simultaneous and sequentially presented characters was carried out. ED's performance did not significantly differ from that of the comparison group on both tasks, unlike LK and RI who exhibited a deficit for sequentially presented characters.

Global and partial letter report

Finally, ED was assessed in letter report tasks. The result indicated that she did not differ from the comparison group in global or partial report.

Table 50: *Phonological ability, RAN, visual memory and letter report scores of ED and the comparison group (scores in bold are for assessments where standardized scores were not available, standard deviations are in parentheses)*

	ED	*Z*	Comparison group mean
Irregular spelling[a]	**0**	**-1.5**	**48.3 (26)**
Nonword spelling[a]	**10****	**-2.0**	**49.3 (11)**
Irregular reading[a]	**23***	**-1.9**	**70 (20)**
Nonword reading[a]	**20***	**-1.8**	**70 (26)**
Blending[β]	90*	-2.1	122 (16)
Spoonerisms[c] (max=20)	**0***	**-1.6**	**14 (6.2)**
RAN pictures[d] (in secs)	**111*****	**2.2**	**60 (8.8)**
RAN digits[d](in secs)	**53****	**2.1**	**31(5.1)**
Global report arrays correct[e] (max=20)	**2**	**-.54**	**5.7 (6.1)**
Global report letters correct[e] (max=100)	**57**	**-.69**	**71 (18)**
Partial report[e] (max=50)	**40**	**.29**	**39 (3.8)**
Visual memory for pictures[f] (max=32)	**9****	**-1.9**	**16 (2.2)**
Visual memory for designs[f] (max=32)	**11**	**-.64**	**13 (2.8)**
Visual memory simultaneous[g] (max=12)	**6**	**.16**	**5.7 (1.6)**
Visual memory sequential[h] (max=12)	**5**	**-.68**	**6.7 (2.3)**

Note: [a]DTWRP (F.R.L.L. 2012), [β]CTOPP; Wagner et al. (1999), [c]PhAB; Frederickson et al. (1997), [d]RAN, PhAB; (ibid.),[e]Letter report tasks, adaptation from Bosse et al. (2007), [f]Athena Test; Paraskevopoulos et al. (1999), [g]adapted from Hulme (1981), [h]adapted from Goulandris and Snowling 1991, **p*<.05, ** *p*<.01

Summary of assessments

Assessments revealed difficulties with both irregular and nonword reading and spelling. ED seemed to have difficulty in assessments of PA and RAN. She also had poor performance in visual memory for pictures but not for designs. ED did not exhibit a letter report deficit.

Rationale for training

It was decided to provide a sublexical training that aimed at improving ED’s spelling skills. ED was towards the end of Year 2 and her sublexical skill was very poor indeed, based on her nonword spelling performance and high rate of non-phonologically appropriate errors. Therefore, it was decided that support for sublexical skills for spelling would be provided. As for LK and RI, it seemed important to put sublexical skills in place before ED moved on to the next school grade.

Training programme

The procedure and duration of the training were exactly the same as those followed for LK and described earlier. The programme began in February 2010 and lasted for nine weeks. A letter outlining the procedure was given to ED’s parents and she practised every day at home for twenty minutes.

Post-training assessment

Post-training assessments were conducted one week and then four months after the end of the training in order to look for gains in performance, and whether these were sustained over time. Results are given in Table 51. Analysis with McNemar's tests revealed no change in performance in spelling and reading of nonwords. ED showed a small but non-significant improvement in irregular word spelling and reading.

Table 51: *Scores for ED on assessments before training and following sublexical and lexical training. Scores for the comparison group are at Time 1 (end of ED's sublexical training) and Time 2 (end of ED's lexical training). Scores in bold are for assessments where standardized scores were not available and represent percentage correct (standard deviations are in parentheses)*

	ED						*Comparison group mean*	
	Pre-training	*Z*	Immediate Post-sublex. training	Delayed Post-sublex. training	Immediate Post-lexical training	Delayed Post-lexical training	T1	T2
Spelling[α]	74	-	81	85	92	90		
Reading accuracy[α]	72	-	88	82	86	84		
Phonological ability[β]	90	-2.1	95	95	95	95		
Irregular spelling[c]	**0**	**-1.5**	**15**	**13.3**	**38**	**33.3**	**48.3 (26)**	**55 (20)**
Nonword spelling[c]	**10**	**-2.0**	**13**	**10**	**25**	**23.3**	**49.3 (11)**	**60 (18)**
Irregular reading[c]	**23**	**-1.9**	**23**	**30**	**37**	**50**	**70 (20)**	**-**
Nonword reading[c]	**20**	**-1.8**	**20**	**20**	**25**	**20**	**70 (26)**	**-**

Note:[α]WIAT-II, Teacher's edition (Wechsler, 2006), [β]blending subtest from CTOPP: Wagner et al. (1999), [c]DTWRP (F.R.L.L. 2012)

Interim summary

Although there were small gains in standardized reading and spelling assessments, the training did not result in improvement of ED's sublexical skill. Therefore a second intervention was designed, this time targeting lexical skills.

Rationale for training

ED had experienced three years of literacy instruction in primary school that focused on phonics, and her weak sublexical skills did not seem to improve as a result of the phonics-based training programme. It was decided to conduct a lexical spelling intervention, since ED might benefit instead from a training that focused on establishing and strengthening orthographic representations. Brunsdon et al. (2002) observed improvement using a lexical reading training in a child with mixed dyslexia who did not seem to benefit from an intensive four-year special remediation programme focusing on "sounding out" words, see also Introduction Chapter 7. The training put in place for ED was based on techniques (such as flashcard and visual imagery) used in previous studies (Brunsdon et al. 2005; Kohnen et al., 2008b, see Introduction Chapter 7) that have targeted lexical processes. The difference between the aforementioned interventions and the one used in the present study was that ED had to devise the pictorial mnemonic herself and embed the misspelled part of the word in the picture.

Training programme

A ten-week programme was developed using whole-word based flash-card and visual imagery techniques, aimed at strengthening lexical processes (after Rowse & Wilshire, 2007; Brunsdon et al., 2002, 2005; Kohnen et al., 2008b; Weekes & Coltheart, 1996; de Partz et al., 1992 described in Introduction Chapter 7). The programme began two months after the delayed follow-up assessment conducted at the end of the sublexical training.

Before beginning the lexical training, two baseline assessments were carried out. The baseline assessments were conducted in November and December 2010. Words were taken from Masterson et al. (2008) and from the Diagnostic Test of Word Reading Processes (FRLL, 2012) and were presented for spelling to dictation (a total of 120 items). The number of words misspelt was 92 at the first baseline assessment and 98 at the second. Performance did not differ significantly between the two (McNemar, p=.21). From the words misspelt at both assessments (N=89), 60 items were selected for the training (low frequency words, such as *sacrifice,* were excluded). The 60 words were divided equally for use between the flashcard and visual imagery techniques. The words used in the training were not the same as the ones used for general assessment.

Procedure

In January, 2011, the lexical training began. At each of the weekly half-hour sessions, a new set of words was introduced. Half of the session was devoted to the imagery technique and half to the flashcard technique, with the order of techniques counterbalanced across sessions. As in Brunsdon et al. (2005) the items included in the training sets each week were matched on number of orthographic neighbours, (Kruskal

Wallis: *p*=.86), number of words that were regularly spelled (*p*=.76), printed word frequency (*p*=.14) and number of letters (*p*=.99). Items were matched on the same variables across the two training techniques (*p*>.05). A description of the two strategies employed is presented next.

Visual Imagery technique

The targeted word was shown to ED with the misspelt part highlighted in bold. ED was asked to think of a picture that depicted the word and to draw it with the word in view. She was then asked to embed the word in the picture. Figure 11 gives an example, where the target was <*mouse*> -> (misspelled as MAS, for English). ED copied the picture with the embedded word, then the word was removed from view, after a delay of ten-seconds she reproduced the drawing with the embedded word. In the case of an error, she was asked to look again at the picture and repeat the last activity. Finally, the participant wrote the word to dictation without the picture.

Figure 11: *Example of pictures with an embedded word (mouse) used for the visual imagery technique*

Flashcard technique

The targeted word was first shown written on a card with the misspelt part highlighted. The tester wrote the word in large letters on an A4 card and ED traced it with her finger. The participant copied the word and it was then removed from view. After a ten-second delay, she reproduced the word the tester dictated. In the case of an error she was asked to look at the word again and the process was repeated. Finally, she wrote the target word to dictation.

The child practiced the items at home daily with her parents following the flashcard or visual imagery procedure depending on the item. Practice lasted for 20 minutes per day; during which the target words were dictated to her for spelling. When there was an error the child looked at the word and wrote it again until accuracy was achieved. As in Brunsdon et al. (2005), at each weekly session with the researcher there was a re-test of items from the previous week. The child was not always 100% correct and the erroneously spelled words were not retrained.

Post-training assessments

Two post-training assessments were conducted: one month later (Time 1) and four months later (Time 2). The tests that had been used prior to lexical training for reading, spelling and phonological ability were employed. Irregular word and nonword reading and spelling to dictation were also administered to a group of bilingual English- and Greek-speaking children (N=8) from ED's class at the Greek afternoon school. This comparison group had an average chronological age of 7;06 (*SD*=0;04). Results are given in Table 51 above. They reveal that at T1 ED showed improvement in irregular word spelling and reading (of 20% in each case), and, to a lesser extent, nonword spelling (13.3%).

Accuracy in spelling the 60 words included in the training before and after training is plotted in Figure 12. There was a significant increase in spelling accuracy from baseline (number correct: 5/60) to T1 (number correct: 38/60) (McNemar $\chi^2=35.03$, $p=.000$). Accuracy at the second follow up assessment (number correct: 33/60) (Time 2) was not significantly different from that at T1 (McNemar $p>.05$), indicating that improvement was sustained over time.

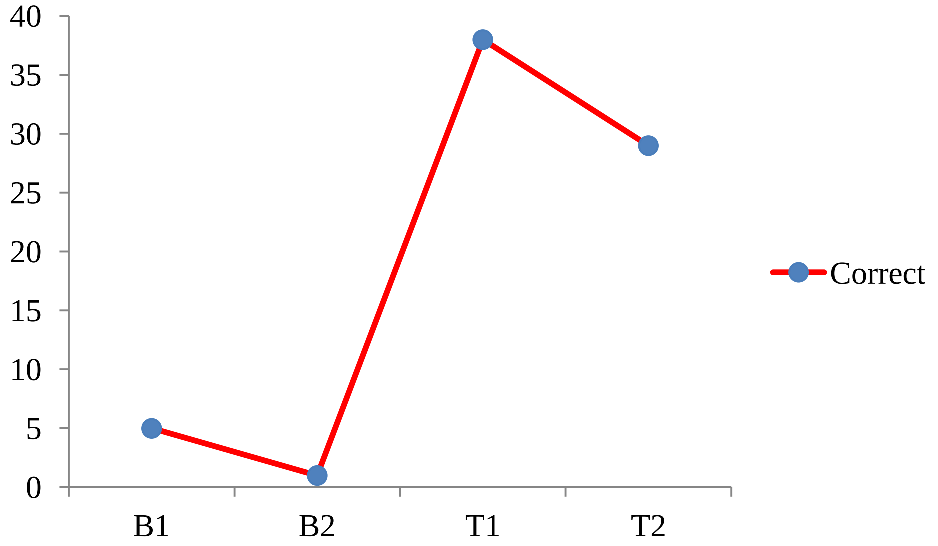


Figure 12: *Accuracy in spelling the 60 items included in the intervention before and after the lexical training for ED*

Note: B= Baseline, T =Time

A comparison of the effectiveness of the visual imagery and flash card techniques was conducted. No difference in improvement was observed for the two (Kruskal Wallis, $p>.5$). ED was asked whether she had a preference for either technique. She reported that she liked both methods and that she thought they both helped with her spelling.

Inspection of generalization of the improvement to untrained words was carried out. Forty-three items that were misspelt in at least one of the two baseline assessments, but that were not included in the lexical training, were re-tested at the T1and T2 post-training assessment. A significant improvement was observed (McNemar, T1 p=.004 and T2 p=.001). Accuracy for the items at B1 was 6/43, at T1 16/43 and at T2 it was 17/43.

Finally, in order to investigate the specificity of the effect of training, the arithmetic subtest from WISC-IV was administered before and immediately at the end of training. ED's score did not show any change (pre-training standard score=80, post-training standard score=80), indicating that the effect of the training was specific to literacy processes. Similarly, same age comparison group children were re-tested in irregular and nonwords at the T2 assessment and their spelling performance did not show significant improvement (see Table 51).

Discussion

Following the lexical training a significant improvement in spelling for the target words, as well as generalization to untrained words, was observed. Both flashcard and visual imagery techniques were found to be effective. The results are in agreement with other training studies targeting lexical processes (Behrmann, 1987; De Partz et al., 1992; Brunsdon et al., 2005; Kohnen et al. 2008b; see also Introduction, Chapter 7). Although a difference in effectiveness of the flashcard and visual imagery techniques was not observed in the present study one might have been found if the strategies had been used at different times in training. Further research looking at the two strategies could shed more light on this.

Summary of case studies 1, 2 and 3

In order to gain a deeper understanding of the pattern of associated difficulties, Table 52 presents the children's scores in cognitive assessments prior to the intervention. Significant differences between children's scores and control groups' performance are marked with asterisks (different control groups were used to make comparisons with each child, please see relevant pages).

Table 52: *Summary of LK, RI and ED's scores in tasks before intervention*

	LK	*RI*	*ED*
	7;03	*7;04*	*7;09*
English measures			
Standard Scores Blending[α] (max=20)	95	100	90*
Spoonerisms[β] (max=20)	0*	4*	0*
RAN pictures[c] (in secs)	65	60	111***
RAN digits[c] (in secs)	46	33	53**
Global report arrays correct[d] (max=20)	-	3	2
Global report letters correct[d] (max=100)	-	73	57
Partial report[d] (max=50)	-	42	40
Irregular word spelling[e] (% correct)	0*	0*	0
Nonword spelling[e] (% correct)	0**	10**	10**
Irregular word reading[e] (% correct)	0*	16.6*	23*
Nonwords reading[e] (% correct)	0**	3.3**	20*
Greek measures			
Standard ScoresBlending[f] (max = 32)	70*	79*	-
Spoonerisms [g](max= 20)	0**	0**	-
RAN pictures [h](in secs)	66	70	-
RAN digits[h] (in secs)	47	45	-
Global report arrays correct[i] (max=20)	-	0	-
Global report letters correct[i] (max=100)	-	55	-
Partial report[i] (max=50)	-	29	-
Irregular word spelling[j](% correct)	0**	5**	-
Nonword spelling[j] (% correct)	0****	20****	-
Nonwords reading[j] (% correct)	0****	25**	-
Visual memory for pictures[k] (max=32)	11	16	9**
Visual memory for designs[k] (max=32)	5*	20	11
Visual memory simultaneous[l] (max=12)	5	7	6
Visual memory sequential[m] (max=12)	3*	3*	5

Note: [α] CTOPP; Wagner et al. (1999), [β] PhAB; Frederickson et al. (1997), [c]Rapid Automatized Naming, PhAB; (ibid.), [d]Letter report tasks, adaptation from Bosse et al. (2007), [e]DTWRP (Forum for Research in Language and Literacy, 2012), [f]Athena Test; Paraskevopoulos et al. (1999), [g]Spoonerism task devised for Greek, adapted from PhAB; (ibid.), [h]Rapid Automatized Namimg, adapted from PhAB;(ibid.), [i]Letter report tasks in Greek, adaptation from Bosse et al. (2007) [j]List of irregular words and nonwords from Loizidou et al. (2009) [k]Athena Test; Paraskevopoulos et al. (1999), [l]adapted from Hulme (1981), [m]adapted from Goulandris and Snowling 1991, *p<.05, ** p<.01, *** p<.001.

All three children had a significant deficit in phonological ability and particularly in the spoonerisms task. Their nonword spelling and reading was also significantly compromised. In agreement with the self-teaching hypothesis (Share, 1995, 1999) children were also significantly impaired in irregular word spelling in contrast to the same age comparison children's performance. This theory predicts that poor phonological decoding (leading to poor nonword reading) would further prevent normal acquisition of orthographic knowledge (see section 3.2). However, at least ED and RI's letter report ability was preserved. This is in agreement with studies that have reported that surface dyslexic participants showed a letter report difficulty whereas phonological dyslexics had a phonological deficit (c.f., Valdois et al., 2003; Dubois et al., 2010; Peyrin et al., 2012, see chapter 6). ED also had significant difficulties in rapid naming tasks is agreement with the double deficit theory. Bowers & Wolf (1993) found children with difficulties in PA and RAN. Finally, LK and RI had a significant difficulty with sequential visual memory which has been found to affect spelling (Romani et al., 1999; Goulandris & Snowling, 1991, see section 3.2).

Next a lexical spelling intervention with a trilingual girl with spelling impairment will be presented.

7.5. Case study: NT[8]

Introduction

This section will report a study with a 10-year-old multilingual girl who exhibited spelling difficulties, in spite of average reading ability in Greek and English. Background details and assessments of reading and spelling will be reported first and then a description of the intervention conducted will be presented. NT attends a morning Greek school in London[9]. When NT began the Greek school she only spoke her mother tongue and she knew some English but no Greek. NT attended the Greek school as her father was a great admirer of the Greek language and civilization. She has one sibling, an older brother, who attends the same school. NT's developmental history, according to her parents, was uneventful and developmental milestones were attained at the appropriate ages, except that she started to speak later than her brother. NT's mother tongue is one of Turkish origin which uses the Latin alphabet, but she is now also a fluent speaker of Greek and English. She speaks English and her mother tongue at home, and with friends. She cannot read or write in her mother tongue and only uses it as a means of communication with her family and friends. At the time the assessment began NT was 10;03. Her teachers reported that her reading was good but her spelling in both Greek and English was very poor. NT's brother has no reported problems with reading or spelling and there is no history of literacy difficulties in the family.

As for the aforementioned case studies, background assessments were administered to NT and the results are given in Table 53. For Greek tests normative data are not available, consequently, three typically developing readers/spellers from the same school and class as NT were recruited to serve as a comparison group throughout the study. The three ten-year-old children were boys (mean age=10;06, *SD*=0;02) matched in age and non-verbal ability to NT. Two of the children were bilingual and the other was trilingual. All were reported by their class teacher to be exhibiting average levels of literacy ability. Years of schooling in the particular setting did not differ for NT and the three boys (number of years in the setting was 4). For the Greek receptive vocabulary assessment a significant difference was found between NT's score and the scores of the comparison group $t(3)=4.17$, $p<.05$.

[8] Part of the research study was presented at the Language 3 conference (Spain, 2012).
[9] The morning school followed the Greek national curriculum. Pupils received instruction in Greek language art for eight hours per week and English literacy for 10 hours per week taught by a native English teacher.

Table 53: *Standardised scores in background assessments for NT and the comparison group (scores in bold are raw scores, standard deviations are in parentheses)*

	NT	*Comparison group mean*
Non-verbal reasoning[α]	108	96 (13.1)
Arithmetic[b]	95	
Digit Span[b]	95	
English receptive vocabulary[c]	87	108 (11.5)
Greek receptive vocabulary[d] (max=174)	**72***	**125 (11.1)**

Note:[α]Matrix Analogies Test Naglieri (1985), [b]subtests from WISC-IV, (Wechsler, 2003), [c] BPVS II (Dunn et al., 1997) norms taken from a bilingual sample, [d]PPVT-adapted for Greek (Simos et al., 2009), * p<.05

Reading and spelling assessments

The results for NT and the comparison group for the reading and spelling tests are given in Table 54.

Table 54: *Standardised scores for reading and spelling assessments for NT and the comparison group (scores in bold are raw scores, standard deviations are in parentheses)*

	NT	Comparison group mean
	English measures	
Comprehension [α]	108	
Accuracy [α]	105	
Rate [α]	84	
Spelling [α]	74	
	Greek measures	
Comprehension [β]	**34**	**41 (3.3)**
Accuracy [c]	**60**	**60 (0.0)**
Rate (in seconds)[c]	**361***	**217(37.1)**
Spelling[c]	**21***	**49.6 (5.7)**

Note:[α]WIAT-II, Teacher's edition (Wechsler, 2006), [b] adaptation of the Neale Analysis of Reading Ability (Neale, Christophers, & Whetton, 1989, adapted by Loizidou, personal communication) [c]test developed by Mouzaki et al., (2007), *p<.05

The results indicated that NT did not have a difficulty in reading comprehension or reading accuracy in either English or Greek, but reading rate and spelling in both languages were impaired (for Greek reading rate $t(3)=3.36$, $p<.05$, $r=.88$ and spelling $t(3)=4.3$, $p<.05$, $r=.92$). Qualitative analysis of spelling errors showed that NT made predominantly phonologically appropriate errors, 83% in English and 97% in Greek (for example, jumped -> *gumpt*, knew-> *new*, for English and πετάνε-> *πεταναι* (they throw), πηγή-> *πειγη* (fountain) , φιλί ->*φιλλη* (kiss) for Greek), whilst the comparison group made 76% in English and 100% in Greek of such errors.

Summary of background assessments

The results of the background assessments indicated that NT showed slow reading speed, poor spelling and weak receptive vocabulary in both English and Greek.

Detailed assessment

Further testing was carried out to investigate lexical and sublexical reading and spelling processes, and to assess PA, visual memory, rapid naming and global and partial letter report span.

Single word reading and spelling to dictation and reading and spelling of irregular words and nonwords

In addition to the same age matched comparison group, two different spelling ability matched comparison groups were formed, one group of children (*N*=10) was matched to NT in terms of performance in the Greek spelling test (Mouzaki et al.) and the other (*N*=11) was matched to NT in terms of performance in the English spelling test (WIAT-II spelling subtest). Children were recruited from the same school as NT, they were all bilingual and the mean age was 8;02 (*SD*=0;06) years for the English spelling comparison group and for the Greek spelling comparison group was 7;07 (*SD*=0;04). The same spelling age matched control children were used in all tasks reported in case NT. A summary of the results of the reading and spelling assessments is given in Table 55.

Results for both English and Greek spelling to dictation, assessed with the 60-word list, indicated a significant difficulty for NT ($t_{English}(3)=3.84$, $p<.01$, $r=.91$ & $t_{Greek}(3)=3.5$, $p<.01$, $r=.89$). For English irregular word and nonword spelling NT's performance was significantly lower than that of both comparison groups, $t_{\mathrm{irregular}}(3)=23.8$, $p<.001$, $r=.99$ & $t_{irregular}(11)=2.3$, $p<.05$, $r=.57$ & $t_{nonword}(3)=9.4$, $p<.01$, $r=.98$ & $t_{nonword}(11)=2.2$, $p<.05$, $r=.55$, respectively; in Appendix C are included NT's spelling errors prior to intervention. For Greek, NT's irregular word spelling differed from that of the same age comparison group, $t_{\mathrm{irregular}}(3)=4.3$, $p<.05$, $r=.92$, and nonword accuracy differed significantly from that of both comparison groups, $t(3)=10.3$, $p<.01$, $r=.99$ and $t(10)=3.8$, $p<.001$, $r=.76$, respectively.

Table 55: *Percentage correct for NT and the chronological age and spelling ability matched comparison groups in single word reading and spelling to dictation (standard deviations are in parentheses)*

	NT	*Z*	Age matched comp. group mean	Spelling ability matched comp. group mean
		English measures		
Reading 60-word list$^{\alpha}$	91.6	-.28	92.8 (3.4)	88.5 (9.8)
Spelling 60-word list$^{\alpha}$	63.3	-1.4	89.5** (5.9)	63 (17.2)
Reading irregular words$^{\beta}$	66.6	-.97	83.3 (12.0)	71.3 (16.3)
Spelling irregular words$^{\beta}$	33.3	-1.4	85.6*** (1.9)	58.3* (10.3)
Reading nonwords$^{\beta}$	93.3	.50	81.1 (21.1)	78.3 (16.0)
Spelling nonwords$^{\beta}$	36.6	-1.4	92.2** (5.1)	75* (16.1)
		Greek measures		
Reading 60-word list$^{\alpha}$	100	-	100 (0.0)	97.4 (2.1)
Spelling 60-word list$^{\alpha}$	43.3	-1.3	87.8** (11.1)	55 (12)
Spelling irregular words^{c}	35	-1.4	85* (10)	40.5 (18)
Reading nonwords^{c}	95	-.86	98.2 (3)	90 (15.2)
Spelling nonwords^{c}	62.5	-1.4	95.8** (2.8)	90*** (6.8)

Note: $^{\alpha}$60-word list (Masterson et al., 2008), $^{\beta}$DTWRP (Forum for Research in Language and Literacy, 2012), ^{c} Greek words and nonwords (Loizidou, et al., 2009), $^{*}p$<.05, $^{**}p$<.01, $^{***}p$<001

Regression analyses using irregular word spelling accuracy as the dependent variable

Regression analyses were used to explore predictors of irregular word spelling accuracy for NT and the comparison groups for irregular words in English and Greek. For the English analyses, the dependent variable was accuracy for the 44 irregular words, 14 from the Masterson et al. word list and 30 irregular items from the DTWRP test. For the Greek analyses the dependent variable was accuracy in 60 irregular words, 40 from the Masterson et al. word list and the 20 from Loizides et al. The predictor variables in each of the analyses were printed word frequency and word length in letters. Values for printed word frequency for the English words were obtained from the Children's Printed Word Database (Masterson et al., 2010), and for the Greek words they were obtained from Ktori et al. (2008).

The analysis in NT's case involved binary logistic regression. For English spelling accuracy the effect of word length was significant, Wald χ^2=3.97, p<.05 but the effect of frequency was not. Simultaneous multiple regression analysis was conducted with the item totals for accuracy in spelling the English irregular words for the children in the age matched comparison group. The results revealed that frequency was a significant predictor (with 38% of variance explained) but word length was not. For the spelling ability matched comparison group, simultaneous multiple regression analysis revealed that word length and not word frequency was a significant predictor. Word length accounted for 34% of variance and frequency 1% of variance (see also Table 56).

For the regression analyses for Greek irregular word spelling, the binary logistic regression analysis involving NT's data revealed that, as for the English data word length was a significant predictor, Wald $\chi 2$=4.29, p<.05, but word frequency was not. The simultaneous multiple regression analysis with the data of the same-age comparison group revealed that both predictors were significant. Frequency explained 6% and word length explained 8% of variance. The same analysis for the spelling ability matched comparison group revealed that word length and not word frequency was significant. Word length explained 12% of variance and frequency 6% of variance.

Table 56: *Results of regression analyses conducted for spelling of irregular words for NT and chronological age and spelling age matched comparison groups.*

	English			*Greek*		
	NT	Age matched comp. group	Spelling matched comp. group	NT	Age matched comp. group	Spelling matched comp. group
	Wald	β	β	Wald	β	β
Freq.	ns	.53**	ns	ns	.24*	ns
Length	4.64*	ns	-.52*	4.29*	-.28*	.34**

Note: ^{ns}=not significant, $^{**}p$<.01, $^{*}p$<.05

Phonological ability and rapid naming

A summary of the results for the PA and RAN tasks is given in Table 57. A letter sound naming test was also administered. Six lowercase high frequency letters (α, κ, π, λ, ε, σ) were used for this task and six lowercase English letters (s, t, n, k, a, o). NT's performance in English and Greek in these tasks did not differ from that of the comparison groups.

Table 57: *Phonological ability and RAN scores of NT and comparison groups (standard deviations are in parentheses)*

	NT	Standard Scores	*Z*	Age Matched Comp. Group	Spelling Matched Comp. Group
			English measures		
Blending (max 20)	16	105	.99	14.33(1.15)	12.80 (2.04)
Spoonerism (max.20)	15		.31	13 (6.6)	12.20 (2.3)
RAN Pictures (seconds)	75		1.4	59.83 (21.8)	61.65 (22.1)
RAN Digits (seconds)	23		.51	20.3 (4.5)	-
RAN Letter sounds (seconds)	18		.95	14.5 (3.3)	-
			Greek measures		
Blending (max. 32)	26	105	-1.3	29.33 (1.15)	21.22 (9.37)
Spoonerism(max.20)	16		.00	16 (5.2)	12.8 (6.1)
RAN Pictures (seconds)	60		.91	67.50 (17.8)	72.78 (15.8)
RAN Digits (seconds)	20		.86	18 (1.7)	-
RAN Letter sounds (seconds)	18		.50	17.5(1.2)	-

Visual memory

The same tasks as the ones used for the aforementioned cases were also administered to NT. The results in the four tasks for NT and a same age and non-verbal ability comparison group (*N*=19) are presented in Table 58. There were no significant differences.

Table 58: *Visual memory task scores of NT and the comparison group (standard deviations are in parentheses)*

	NT	*Z*	Comparison group
Visual memory Pictures (max 32)	18	-.58	17.11 (6.2)
Visual memory Designs (max 32)	15	.19	14.53 (4.1)
Visual memory Simultaneous (max 12)	5	-1	5.68 (2.4)
Visual memory Sequential (max 12)	5	-	6.11 (2.7)

Global and partial letter report

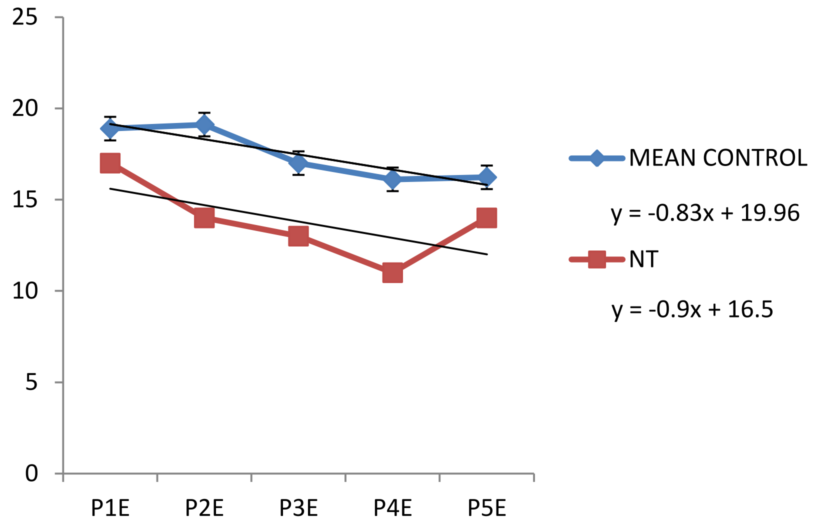
NT's performance was contrasted with that of 9 typically developing readers and spellers attending the same school, and who were all bilingual. Table 59 gives the results for NT and the comparison group. In global report, NT showed impairment in the task in both the Greek and English versions, $t_{arrays}(9)=2.2$, $p<.05$, $r=.6$ and $t_{arrays}(9)=1.9$, $p<.05$, $r=.53$, $t_{total\ letters}(9)=2.3$, $p<.05$, $r=.61$ and $t_{total\ letters}(9)=3.1$, $p<.01$, $r=.71$, respectivelly). For partial report NT's performance in both versions was not significantly lower than that of the comparison group.

Table 59: *Scores for NT and the comparison group in the letter report tasks (standard deviations are in parentheses)*

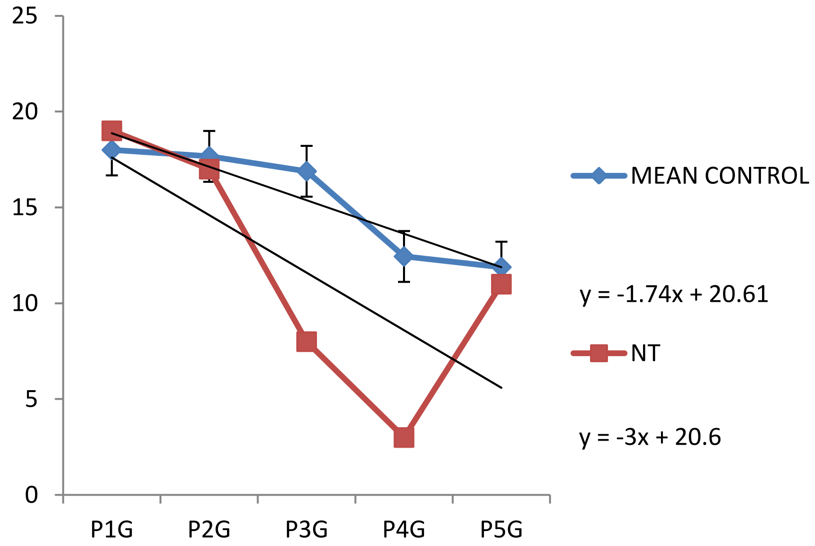
	NT number correct	*Z*	Comparison group mean correct
Global report arrays English (max=20)	4.00*	-1.3	11.78 (3.3)
Global report arrays Greek (max=20)	1.00*	-.58	6.67 (2.7)
Global report letters English (max=100)	70.0*	-.48	88.22 (7.3)
Global report letters Greek (max=100)	58.0**	-1.4	79.13 (6.6)
Partial report English (max=50)	42.0	-1.4	43.50 (5.3)
Partial report Greek (max=45)	28.0	-1.1	38.00 (6.1)

Note: ** $p<.01$, * $p<.05$

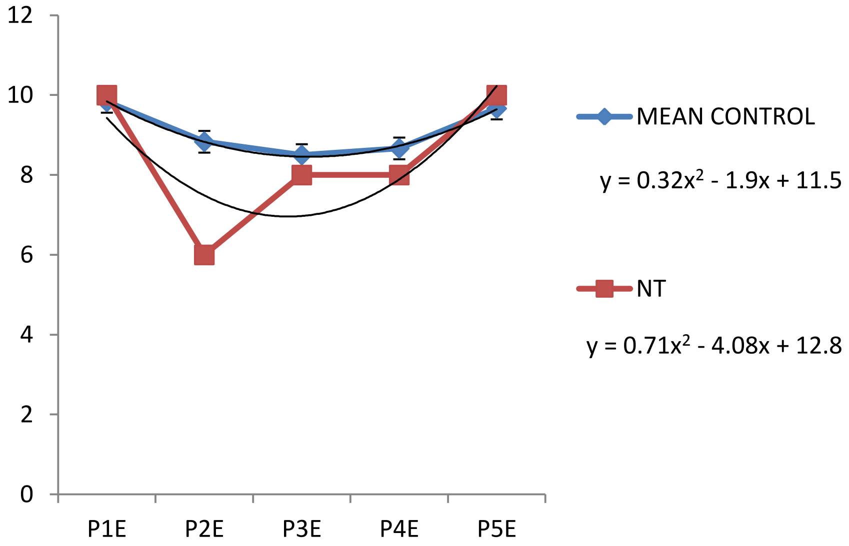
The effect of letter position on accuracy for both global and partial report was examined in order to investigate NT's performance in relation to that of the comparison group (the results are presented in Figure 13a&b for global report, c&d for partial report).



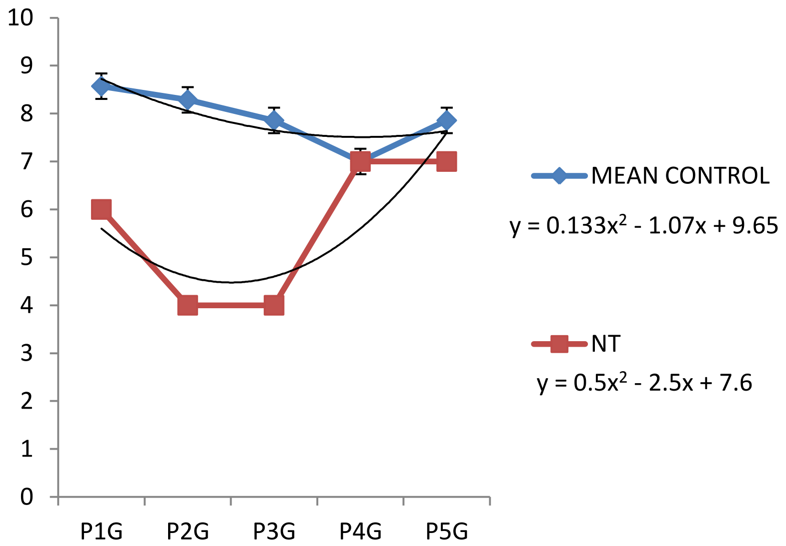
a. Global report English



b. Global report Greek



c. Partial report English



d. Partial report Greek

Figure 13a & b, c & d: *Correct responses for global and partial letter report according to letter position for NT and the comparison group*

Note:P=Position, E=English, G=Greek

The global report profile of the comparison group was characterised by a linear function for both languages, $F_{English}(1,9)=16.1$, $p<.01$, $\eta^2=0.64$ and $F_{Greek}(1,9)=66.1$, $p<.0001$, $\eta^2=0.88$, and this was also the case for NT. For English language, at positions 1, 2 and 5 NT performed significantly lower than the comparison children (correct P1 for NT=17 and for comparison group =18.89 (*SD*=0.92); $t_{P1}(9)=1.9$, $p<.05$, correct P2 for NT=14 and for comparison group=19.11 (SD=1.05); $t_{P2}(9)=4.6$, $p<.001$ & correct P5 for NT=14 and for comparison group=18 (SD=2.1); $t_{P5}(9)=1.81$, $p=.05$). For positions 3 and 4 the difference only approached significance (correct P4 for NT=11 and for comparison group=16.11 (SD=3.03); $t_{P4}(9)=1.6$, $p=.07$ & correct P3 for NT=13 and for comparison group=17 (SD=2.6); $t_{P3}(9)=1.46$, $p=0.09$). For Greek language, at positions 3 and 4, NT performed significantly lower than the comparison children (correct P3 for NT=8 and for comparison group=16.89 (SD=2.4); $t_{P3}(9)=3.51$, $p<.01$ & correct P4 for NT=4 and for comparison group=12.44 (SD=2.7); $t_{P4}(9)=2.96$, $p<.01$). For positions 1, 2 and 5 the difference was not significant (correct P1 for NT=19 and for comparison group =18 (SD=2.06); $t_{P1}(9)=0.46$, $p>.05$, correct P2 for NT=17 and for comparison group=17.67 (SD=2.06); $t_{P2}(9)=0.31$, $p>.05$ & correct P5 for NT=11 and for comparison group=11.89 (SD=2.6); $t_{P5}(9)=0.32$, $p>.05$).

In partial report (Fig. 13c&d), performance in the English version the comparison group was characterised by a significant quadratic trend, $F(1,9)=14.7$, $p=.009$, $\eta^2=0.71$, and NT reported letters in all positions but not at a comparable level to that of the comparison children. NT's performance at position 2 approached to become significantly lower than the control's one (NT=6 comparison group mean= 8.5 SD=1.04, $t(9)=1.62$, $p<.08$). In the other positions performance was not significantly different. Performance in Greek language task of the comparison group was characterized by a quadratic trend, $F(1,9)=5$, $p=.06$, $\eta^2=0.41$. Similarly with English partial report NT reported all letters but in a very atypical profile. Particularly, she scored significantly lower at the three initial positions than the comparison group (P1: NT=6 vs mean controls=8.57, SD=0.78, $t(9)=3.08$, $p=.01$, P2: NT=4 vs mean controls=8.2, SD=0.01, $t(9)=3.5$, $p=.006$, &P3: NT=4 vs controls' means 7.8, SD=1.2, $t(9)=2.9$, $p=.01$) but no different than controls at the two final ones indicating a right-side- bias. NT's performance in English also indicates higher accuracy at letters appearing at the right than at the left of fixation for partial report.

Summary of pre-intervention assessment

The assessments revealed that NT's nonverbal reasoning abilities, reading comprehension and reading accuracy were age appropriate, however her reading rate was slow and receptive vocabulary was weak in both English and Greek. NT also had difficulty in spelling that involved spelling irregular words as well as nonwords in both languages. Regression analyses with irregular word spelling accuracy as the dependent variable and word frequency and word length as predictors revealed that word length but not word frequency was significant. This indicates a reliance on sublexical processing for spelling as word length is considered to be a marker of sublexical processing for both reading and spelling (e.g. Share, 2008; Spencer, 2010, see section 3.3). Qualitative analysis of NT's spelling errors in both languages showed that the majority of misspellings were phonologically appropriate, again suggesting reliance on sublexical processing for spelling and a difficulty in establishing orthographic representations. NT's weak receptive vocabulary may have been a contributor to this problem, or even the sole cause. Recent research has emphasized the role of vocabulary knowledge in competent spelling of vocabulary knowledge. For example, Ouellette (2010, see section 3.2.) showed, in an experimental study with 7-year-old children, that providing semantic knowledge for printed words improved spelling performance. In this study the effectiveness of reading versus spelling training on spelling was compared, and half of the trained words were coupled with semantic information in each training condition. The spelling intervention was found to be more effective in producing accurate spelling, and if the training was coupled with semantic information it was even more beneficial. However, if lack of semantic support for lexical/orthographic representations was a major factor in NT's literacy difficulties then one would expect that her irregular word reading and reading comprehension would also be compromised. In fact, as noted above reading comprehension was unimpaired for both English and Greek, and irregular word reading accuracy in both languages was not different from that of typically developing readers. Further assessments revealed that NT did not appear to have difficulties in visual memory, PA or RAN. However, assessment on the letter report tasks indicated a weakness. In both the English and Greek versions of the global report task NT showed worse performance than the comparison group but performance in the partial report tasks did not differ from that of the comparison group. This dissociation of global and partial report performance was also reported for the child described next, RF. A closer inspection of position performance in partial report indicated a right sided bias (more pronounced for Greek) in comparison to the comparison groups. A similar performance in in a dyslexic child for partial report was reported by Valdois et al. (2011), also see Chapter 6.

A weakness in letter report has been associated in the literature with a difficulty with irregular words in particular (Valdois et al., 2003). NT presented with a letter report difficulty without any indication of phonological impairment, in agreement with previous reports of a selective difficulty of simultaneous multi-character processing reported by Bosse et al. (2007; 2009) and Lowe (2009). However, NT also had difficulty spelling nonwords, suggesting a profile of mixed dysgraphia. More generally, NT showed the pattern of a Type B speller (Frith, 1980), that is, adequate reading performance in the face of poor spelling. Lowe (2009) found that the majority of the Type B spellers in her sample (56%) showed a selective letter report deficit. The remainder of the sample exhibited either a phonological deficit, or both a phonological and a letter report deficit.

The intervention programme

According to the assessments, the locus of NT's impairment was with both lexical and sublexical spelling processes. In addition, NT presented with a deficit in letter report without a phonological impairment, similar with previous reports of a selective deficit of simultaneous multi-character processing. However, NT also seemed to have difficulty spelling nonwords, suggesting mixed dysgraphia. Up to now, most of the intervention case studies either focus on phonological or surface dyslexia and dysgraphia. Mixed dyslexia or dysgraphia is less reported (Valdois et al., 2011). Additionally, interventions with multilingual children are sparse and this is the unique contribution of the intervention case study reported.

It was decided that, given NT's age and the impending move to secondary school where poor spelling and weak vocabulary skills would be even more of a disadvantage than in her current setting, she would benefit most from an intervention that focused on building lexical-orthographic representations and vocabulary. Whole-word based flash card and visual imagery techniques were employed for establishing orthographic entries, after Rowse and Wilshire, 2007; Brunsdon et al., 2005, 2002; Kohnen et al., 2008; Mavrommati and Miles, 2002; Weekes and Coltheart, 1996; de Partz et al., 1992, and intervention also targeted vocabulary knowledge of the taught items (see also Introduction Chapter 7). According to Cummins (2007), in research conducted with multilingual children, literacy achievement relates to the English language learner's ability to associate knowledge from his/her first language to the second language. Watts-Taffe and Truscott (2000) also noted that teaching a new word should trigger a pre-existing concept and this can be achieved by providing examples, using techniques such as drama and visual depictions. A lexically-based spelling intervention seemed justified since the assessments indicated (including the lack of a frequency effect in irregular word spelling and the fact that a preponderance of errors were phonologically appropriate) difficulty establishing lexical representations.

Method

Stimuli

Two baseline pre-intervention assessments were carried out. Words from the Masterson et al. 60-word list, from Loizides et al. and from the DTWRP were presented for spelling to dictation (with a total of 120 English and 100 Greek words). Accuracy did not differ significantly across the two baseline assessments for English (McNemar, χ^2=.008, p=.92) and for Greek (χ^2=.010, p=.92). Items misspelled at both baseline assessments were included in the intervention, which lasted nine weeks and targeted 54 English and 54 Greek words[10].

The targeted English and Greek words were divided for use between the flashcard and visual imagery techniques. As in Brunsdon et al. (2005), words used in each technique were closely matched for frequency, regularity and number of letters in both languages (Kruskal Wallis English frequency: χ^2= 2.009, p=.156, regularity: χ^2=.291, p=.589 length: χ^2=.013, p=.417 Greek frequency: χ^2=.288, p=.592, regularity: χ^2=.009, p=.753, and length: χ^2=.162, p=.688). Items included in each intervention session were matched for frequency (Kruskal Wallis: English: χ^2=.81, p=.999 and Greek: χ^2=.000, p=1) and number of letters (English: χ^2=.013, p=1 and Greek: χ^2=.003, p=1) across the sessions.

Intervention method

At each of the nine weekly intervention sessions, a new set of words was introduced. In each session 15 minutes each were devoted to the visual imagery and flashcard techniques, and 30 minutes for each language. Order of language and techniques was counterbalanced among sessions. The Intervention techniques are presented in section 7.4. (case study ED). A significant inclusion made during both techniques was that the word’s meaning was also explained. In that way NT would be able to relate the new information with her pre-existing knowledge either in her mother tongue or in her second or third language (Watt-Taffe & Truscott, 2000; McWilliam, 2000;Cummins, 2007). The importance of connecting the pre-existing semantic knowledge with the

[10] The total number of words misspelt in both languages was 121, however, in order to have an equal number of matched items in each intervention session, a total of 13 low frequency items were excluded.

orthography of the misspelled word as noted before was highlighted by Cummins (2007, p.1) who claimed "the key to literacy engagement for English language learners is to connect what they know in the first language to English". In Figure 14 an example of the word *seal,* in Greek <φώκια> /fokjia/ :seal ->(misspelled as ΦΟΚΙΑ, for Greek), included in the visual imagery technique in given.

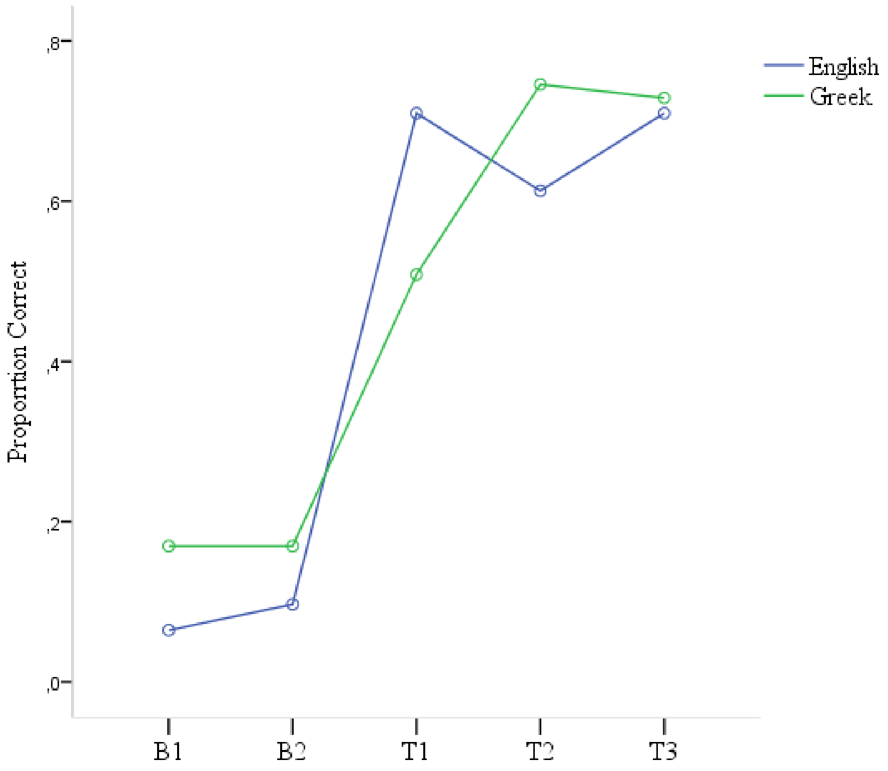
Figure 14: *Example of picture with an embedded word (seal, for Greek: φώκια/fokja/) used for the visual imagery technique*

NT practiced the items at home daily with her parents following the flashcard or visual imagery procedure depending on the item. Practice lasted for 20 minutes per day; during which the target words were dictated to her for spelling. When there was an error the child looked at the word and wrote it again until accuracy was achieved. As in Brunsdon et al. (2005), at each weekly session with the researcher there was a re-test of items from the previous week. The child was not always 100% correct and the erroneously spelled words were not retrained.

Results

Three follow-up assessments were conducted at different times: immediately at the end of training (T1), one month later (T2) and four months later (T3). In Figure 15 a plot of the results is given. For English spelling there was a significant increase in spelling accuracy from baseline to T1 (McNemar χ^2=41.023, p=.0001). Accuracy at the second follow-up assessment (T2) was not significantly different from that at T1 (McNemar p>.05), and accuracy did not significantly differ between T2 and 3 (McNemar χ^2=.593, p>.05). This indicates that, for English, the training resulted in a substantial improvement in accuracy and the improvement was sustained over time. For Greek spelling there was a significant increase in spelling accuracy from baseline to T1 (McNemar χ^2=17.92, p=.0001). Accuracy at T2 was not significantly different from that at T1 (McNemar, p>.05), and finally accuracy did not differ significantly between T2 and T3 (McNemar, p>.05). This indicates that, for Greek also, improvement in spelling accuracy as a result of the intervention was sustained over time. See also Table 60 which provides NT's gains per type of words for each language.

Figure 15: *Summary of NT's performance in English and Greek spelling during and after the programme (proportion correct).*



Note= B= Baseline, T =Time

No difference in improvement was observed for the visual imagery and flash-card techniques for either language (Kruskal Wallis, p_s>.05). NT was asked whether she had a preference for either technique. She reported that she liked both methods and that she thought they both helped with her spelling.

Table 60: *Percentage correct in spelling irregular words and nonwords before and after the training for NT (standard deviations are in parentheses)*

	NT		Age matched comparison group mean	Spelling matched comparison group mean
	Pre-training	Post-training		
English measures				
Irregular[α]	33.3***	66.6**	85.5 (1.9)	58.3 (14.3)
Nonwords	36.6**	76.6	92.2 (5.1)	75 (16.1)
Greek measures				
Irregular[β]	35*	70	85 (10)	40.5 (17.9)
Nonwords	62.5**	80*	95.8 (2.8)	90 (6.8)

Note: [α]DTWRP (FRLL, 2012), [β] Loizidou et al. (2009), *p<.05,**p<.01, ***p<.001, comparisons are between NT and AMCG.

Improvement in spelling performance was also assessed by means of the WIAT-II spelling subtest for English and Mouzaki et al.'s spelling test for Greek. In the former, NT achieved a standardized score of 95 at T3 (versus 74 pre-intervention), and in the Greek test she achieved 60% correct at T3 (versus 35% correct pre-intervention). NT also showed a gain in receptive vocabulary. For English, on the BPVS, she obtained a standardized score of 102 at T3 (versus 87 pre-intervention), and in the Greek receptive vocabulary test a score of 51% correct at T3 (versus 37% pre-intervention). It was also aimed to see if improvement was obtained for reading rate, since if the intervention was successful in improving lexical skills this might improve speed of reading. For English, on the WIAT-II, reading rate assessment NT obtained a standardized score of 85 at T3 (versus 84 pre-intervention), for Greek time taken for reading the text was 260 seconds at T3 (versus 361 seconds pre-intervention). Reading rate for Greek at T3 was no longer significantly different from that of the comparison group (mean=217 secs, *SD*=37.1)

In order to ascertain whether there was a difference in NT's improvement in spelling according to awareness of the meanings of the target words, English and Greek words used for the intervention were divided into two groups: those whose meanings were known and those whose meanings were unknown. NT was asked during the intervention if she knew the meanings of the target items. Results indicated that NT showed significant improvement for both known (English 30/34 and Greek 28/33) and unknown words (English 9/20 and Greek 10/21) (McNemar$_{English}$ χ^2=30.03 p<.0001 and McNemar$_{Greek}$ χ^2=30.03 p<.0001). However, improvement was greater for known words, English 88% (McNemar, *p*<.001) than unknown words (45%, χ^2=11.7, *p*<.001). Similarly in Greek, NT improved in familiar words 85% and in unfamiliar ones 48%, χ^2=8.53, *p*<.01.

In order to investigate the specificity of the effects of the intervention, the arithmetic subtest from WISC-IV (Wechsler, 2003) was administered before and immediately at the end of the training. NT's score did not show any change (pre-intervention standard score=95 and post-intervention score=95), indicating that improvement was specific to spelling.

Discussion

The case study involved a trilingual child who was found to have mixed dysgraphia in English and Greek. NT exhibited a weakness in spelling irregular words and nonwords in both languages when her spelling performance was compared with that of comparison children matched in age and non-verbal ability. Assessment of receptive vocabulary revealed weakness in English and Greek. No difficulties were observed in PA, rapid naming or visual memory, however, NT's performance was significantly lower than that of the comparison children in reporting arrays of briefly presented letters. This difficulty has also been reported in relation to poor spelling by Lowe (2009), and in relation to poor reading by Bosse et al. (2007), also see Chapter 6. These researchers found in a sub-sample of dyslexic (Bosse et al., 2007) and dysgraphic (Lowe, 2009) children, participants with a selective letter report deficit but not a phonological deficit. This result corroborates with our case study as there was not any evidence that NT had impaired phonological ability.

The report of NT adds to a growing body of research which suggests that a spelling difficulty may result from a variety of deficits. It was found that NT's spelling improved following the intervention as did her receptive vocabulary. The results indicate that when intervention targets the specific difficulty it is successful, in agreement with the arguments of Kohnen and Nickels (2010). Additionally, the success of the intervention may be attributed to integrating NT's background knowledge and vocabulary in teaching the spellings of the words. Watts-Taffe and Truscott (2000) stress the significance of focusing on vocabulary growth and development in the multilingual classroom.

In the intervention, two different intervention techniques were employed: a flashcard strategy and a visual imagery strategy. Both were found to be effective in that improvement in spelling performance was observed at both immediate post-intervention and delayed post-intervention assessments. These results corroborate other English and Greek intervention studies targeting lexical processes (Behrmann, 1987; De Partz et al., 1992; Mavrommati & Miles, 2002; Brunsdon et al., 2005, see also Introduction, Chapter 7). As in the case of ED, no difference was found in the results obtained with the two techniques.

Apart from a difficulty with spelling, pre-intervention assessment had indicated that NT's reading rate was slow. When assessed following the intervention NT's reading rate for Greek showed improvement. This is in agreement with other findings indicating that training in spelling can generalize to reading ability (Kohnen et al., 2008a; Brunsdon et al., 2005, although these studies assessed only reading accuracy and not rate). The reading rate improvement in NT's case may have been due to improvement in vocabulary knowledge. It is not clear why improvement was not found in reading rate for English though. Further research to improve our understanding of the factors that lead to generalization with spelling interventions is called for.

Comparison of the effectiveness of spelling intervention for case study ED and NT

Although NT and ED did not have similar age or similar underlying deficit triggering the spelling difficulty, an attempt will be made to compare the effectiveness of the lexical spelling intervention used to remediate the children's spelling difficulty (see also Table 61). A lexical spelling intervention was carried out for both cases using visual imagery and flashcards strategy similar to the ones used in previous successful cognitive neuropsychology intervention case studies (c.f., Behrmann, 1987; De Partz et al., 1992; Mavrommati & Miles, 2002; Brunsdon et al., 2005, see also Introduction, Chapter 7). A similar set of 120 English words was used (Masterson et al. 2008 and from the Diagnostic Test of Word Reading Processes (FRLL, 2012) as a baseline assessment in English language for both case studies. 60 misspelt items at both baseline assessments were used for ED's intervention and 54 for NT's intervention. The first intervention lasted 10 weeks and the second 9 weeks (see for details the *Training programme* section presented in each case report). Table 61 presents ED and NT's scores in English irregular and nonword spelling prior and after the intervention in order to allow comparisons.

Table 61: *Percentage correct in spelling English irregular words and nonwords before and after the training for ED and NT*

	ED		*NT*	
	Pre-training	Post-training	Pre-training	Post-training
	English measures			
Irregular[α]	13.3	33.3	33.3	66.6
Nonwords	10	23.3	36.6	76.6

Note: [α]DTWRP (FRLL, 2012)

Both NT and ED showed improvement in irregular and nonword spelling. This finding indicates that the lexical route targeting intervention was successful for both children. For NT a significant generalization in nonword spelling was also observed (40% improvement), however the same rate of improvement was not observed for ED (13.3% of improvement in nonword spelling). This difference between ED and NT in spelling nonwords may have to do with the children's pre-intervention performance. ED had a difficulty not only in nonword spelling but also in other tasks tapping phonological processing (such as phonological ability and rapid naming). NT on the other had did not have a difficulty in phonological ability and rapid naming; however she had difficulty in tasks tapping simultaneous multi-character processing ability. ED did not have a difficulty in this task and also her spelling errors in English were mainly non-phonological whereas NT's were phonologically appropriate. Therefore, ED's phonological processing deficit might have been more severe in comparison to NT's difficulty. The finding is also in agreement with previous studies reporting that children with a double deficit of phonological awareness and rapid naming experience the most severe difficulties in reading and spelling (e.g., Papadopoulos et al., 2009; Torppa et al., 2013).

Next an intervention with a 12 year old Greek speaking dyslexic boy will be presented.

7.6. Case study: RF[11]

Introduction

This section reports a study with a twelve year-old monolingual Greek speaking boy, RF, who exhibited reading and spelling difficulties. The significance of the study derives from the fact that this is one of the relatively small number of detailed investigations of cases of developmental dyslexia/dysgraphia in Greek. Investigations of the possible causes of RF's literacy difficulties, using the tasks employed with the other case studies are reported, and the intervention targeting multi-letter processing that he took part in is described.

RF was aged 12;08 and attending a state school in Greece when the study was carried out. He had one sibling, a younger brother, who, based on his parents' report, was a precocious reader (he learned to read when he was four-years-old on his own). RF's developmental history was uneventful and developmental milestones were attained at the appropriate ages. RF's mother tongue was Greek and this was the only language spoken by his family. RF's parents were both educators, working in secondary education, teaching modern and ancient Greek. No one else in RF's family has reading or spelling difficulties. RF was not able to learn to read and write when he was in the first grade of school, despite support from his parents and a private tutor. At the end Grade 2 he was still reading by means of syllabifying words (a technique typically used by children in the very initial stages of learning to read). The private tutor did not follow a phonics-based programme, according to RF's parents. RF's reading and spelling difficulty led his parents to look for further help. When RF was ten years old he was assessed by the Greek educational department responsible for assessing children and adolescents with reading and spelling difficulties. The assessment concluded that RF had developmental dyslexia.

At the time the current assessments began, i.e., when RF was 12;08, his parents reported that his reading and spelling were very poor and that his reading was so laborious that he could not follow subtitles on the television screen (many programmes on Greek television are imported from abroad and presented in their original language with subtitles). RF's slow reading was of great concern to his parents as he had problems comprehending difficult school subjects without having someone read them aloud. RF had received additional help from a tutor for the subject Ancient Greek

[11]Part of the study is published in a paper in the journal *Cognitive Neuropsychology*.

during the course of the school year. The tutorial help involved working on homework assignments. This was the only additional help he had had since the private tutor in Grade 1.

The same background assessments were admnistered to RF as to the previous cases and the results are given in Table 62. The Peabody Picture Vocabulary Test, adapted for Greek by Simos et al. (2011), was administered in order to assess receptive vocabulary. For this test normative data are not available. Four monolingual Greek speaking typically developing readers/spellers from the same school as RF were recruited to serve as a comparison group. The comparison group consisted of two boys and two girls (mean age: 12;06, *SD*=0;06, range 12;03-13;06) matched in age and non-verbal ability to RF. These children served as the comparison group for the background assessments reported in Tables 62 and 63 and for Tables 70 and 71 reported later. A different group of eleven children matched to RF for age and non-verbal ability served as a comparison group for the detailed assessments and in the one-minute nonword reading task reported in the next two sections (mean age of the comparison group children was 12;03, *SD*=0;05, range 11;09-13;06).

Table 62: *Standardised scores in background assessments for RF and the comparison group (scores in bold are raw scores, standard deviations are in parentheses)*

	RF	Comparison group mean
Non-verbal reasoning[α]	117	111 (0.88)
Arithmetic[b]	140	129 (2.1)
Digit Span[c]	115	104 (0.3)
Vocabulary[d] (max correct:174)	**154**	**146** (6.2)

Note:[α]Matrix Analogies Test (Naglieri, 1985), [b] and [c] arithmetic and digit span subtests from WISC-III (Georgas et al., 1997), [d] PPVT (adapted for Greek, Simos et al., 2011).

Reading and spelling assessments

Standardised measures

The Reading Test Alpha (Panteliadou & Antoniou, 2007) is a standardized reading test and was used for the assessment of aspects of RF's reading. The test measures four components: 1) reading comprehension, 2) morphological and syntactic awareness, 3) text reading rate and 4) single item reading accuracy. Test-retest reliability for all tasks ranges between .74 and .87. The reading comprehension measure involves reading texts and responding to multiple choice questions, and morphological awareness involves, for example, filling in the gap in sentences with the appropriate grammatical form of a provided word. Reading rate is assessed using a text and involves recording the total number of words read in one minute. Reading accuracy involves two subtasks: reading aloud words and nonwords and lexical decision. The reading aloud subtask involves the presentation of a printed list of 53 words (mean number of letters = 10.5, *SD*=3.3) and 24 nonwords (mean number of letters = 9.6, *SD*=3.1). The words and nonwords are intermixed and of increasing difficulty, according to the test manual. The lexical decision subtask involves 20 words (mean number of letters = 6.1, *SD*=1.1) and 16 non-words (mean number of letters =7.1, *SD*=1.8) presented intermixed in nine printed arrays (of three, four and five items in each array). The child is asked to read through the arrays silently and to report to the tester which of the items are words. The overall score for reading accuracy in Test Alpha consists of number of items read correctly in the reading aloud subtask plus number of words and nonwords correctly identified as such in the lexical decision task.

For spelling, RF was assessed with a single word spelling-to-dictation test developed by Mouzaki et al. (2007) used in previous case studies as well as in the group study, and with a text production sub-test that assesses spelling ability and coherence (Porpodas, Diakogiorgi, Dimakou, & Karantzi, 2007). In the text production test children are asked to produce a piece of written prose based on four related pictures (Porpodas et al., 2007). Two scores are provided. The first, spelling ability, involves dividing the number of correctly spelled words in the text by the number of misspellings multiplied by 100. The second score, for coherence, involves assigning points to categories based on the depth of information given. Test-re-test reliability is .79 for the spelling ability assessment and .57 for coherence.

Experimental measures

In order to obtain a measure of lexical and sublexical reading skill the single words and nonwords from the Reading Test Alpha reading accuracy measure on a separate testing occasion ten days after the other components of Test Alpha had been assessed. Single word and nonword naming latency and accuracy were assessed by presenting the items on the computer[12] in blocks, with the nonwords presented first followed by the words. Nonword stimuli were presented first following the administration procedure of a recently developed reading test that assesses lexical and sublexical skills (FRLL, 2012). Stimuli were presented centered on the screen of a Dell Inspiron portable lap-top computer with Windows 7. Font was Consolas size 14. Vocal reaction times were extracted from the sound files using the *Checkvocal* programme developed by Protopapas (2007). In order to be consistent with the Douklias et al. study, the latencies were calculated in milliseconds from the time the stimuli appeared until the child provided a verbal response (threshold was set at 60 dB). Only correct responses were included in calculating the means.

An additional reading assessment was devised to obtain a measure of nonword reading rate, comparable to the measure used in the Reading Test Alpha for obtaining text reading rate. Stimuli comprised 50 nonwords ranging in length from five to 16 letters (mean number of letters=10.8, *SD*=2.4). The items had the same inflectional endings as nouns and were devised by reversing the syllables of real words in order to create pronounceable nonwords. A list of the nonwords can be found in Appendix A.6. RF was asked to read as many nonwords as possible in one minute.

Table 63 reports the results of statistical testing for the key reading and spelling tasks against the results of the typically developing comparison group. RF showed poor performance in the standardized measures of text reading rate, $t(4)=10.8$, $p<.001$, $r=.98$, reading accuracy, $t(4)=18.6$, $p<.0001$, $r=.99$, single word spelling, $t(4)=5.2$, $p<.01$, $r=.87$ and spelling in text, $t_{spelling}(4)=12.8$, $p<.01$, $r=.99$, $t_{coherence}(4)=6.2$, $p<.05$, $r=.95$. On the experimental measures RF was impaired in single word naming latency, $t(4)=3.2$, $p<.05$, $r=.85$, and accuracy, $t(4)=9.1$, $p<.001$, $r=.97$. Qualitative analysis of RF's spelling errors revealed that the majority (93%) were phonologically plausible. Examples of RF's phonologically plausible errors are *πετάνε*-> πεταναι: /petane/ (they throw), *πηγή*-> πιγη: /piyi/ (fountain), *αυτοκίνητο* ->αυτοκήνιτο /aftokinito/ (car)).and with Study 1 and 2.

[12] Computer-presented tasks were programmed using the DMDX programme developed by Forster and Forster (2003).

Table 63: *Standardised scores for reading and spelling assessments for RF and the comparison group (Scores in bold are raw scores, standard deviations are in parentheses)*

	RF	*Z*	Comparison group mean
	Standardised measures		
Reading comprehension [a]	108	-1.1	119 (1.1)
Morphological awareness[a]	125	.84	119 (0.59)
Text reading rate [a]	67***	-1.7	125 (4.8)
Reading accuracy [a]	81****	-2.5	108 (1.3)
Single-word spelling-to-dictation (max correct = 60)[c]	**16****	**-1.3**	**51 (6.0)**
Spelling based on written text (max correct = 100)[d]	**67****	**-1.5**	**96.7 (2.0)**
Coherence based on written text (max score = 50)[d]	**45***	**-1.5**	**48.6 (0.5)**
	Experimental measures		
Single-word reading latency (msecs)[a]	**1719***	**2.4**	**887 (235)**
Single-word reading accuracy (max correct = 53)[a]	**42*****	**-2.9**	**51.7 (0.95)**
Nonword reading latency (msecs)[a]	**1802**	**2.1**	**1112(334)**
Nonword reading accuracy (max correct = 24)[a]	**16**	**-.89**	**19.5 (1.9)**
Nonword reading rate [b]	**17**	**-1.1**	**23 (5.4)**

Note: [a]Reading Test Alpha (Panteliadou & Antoniou, 2007) [b]Experimental task of nonword reading rate [c]Single word spelling to dictation test (Mouzaki et al., 2007) [d]Diagnostic test of difficulties in written production (Porpodas et al., 2007), * $p<.05$, ** $p<.01$, *** $p<.001$, **** $p<.0001$

Summary of assessment results

The background assessments revealed that RF showed no evidence of deficits in non-verbal reasoning, verbal short-term memory or receptive vocabulary, and that he had a score in the very high ability range for arithmetic. Tests of reading and spelling showed no significant deficits in the areas of reading comprehension, morphological awareness, or nonword reading. Deficits were found for text reading rate, text reading accuracy, single word reading accuracy, single word naming latency, single word spelling, and spelling in text.

As noted in the literature review (section 7.1.3.), slow word reading, poor irregular word spelling, and lack of evidence of a phonological deficit associated with the profile of developmental surface dyslexia in Greek poor readers by Douklias et al. (2009). Since slow word reading was identified in the initial testing with RF it was decided to examine for further indications of the surface dyslexia subtype with detailed assessments reported in the next section.

Detailed assessments

RF was first administered a test of irregular word and nonword spelling to dictation, since a selective deficit for irregular word spelling was the second characteristic of surface dyslexia in Greek reported by Douklias et al. (ibid). The detailed testing also involved assessments of phonological ability, rapid naming, print exposure, sentence-printed word matching with homophones, visual memory, and letter report.

Spelling of irregular words and nonwords

The word and nonword stimuli were taken from the study of Loizidou-Ieridou et al. (2009), who had selected the items to investigate spelling development in Greek speaking children. There were 20 irregular words and 40 nonwords. The results are given in Table 64. For irregular word spelling RF was significantly less accurate than the comparison group, $t(11)=7.1$, $p<.0001$, $r=.90$. By contrast, for nonwords RF's accuracy was not significantly different from that of the comparison group $t(11)=0.0$, $p=0.5$. Qualitative analysis of RF's spelling errors showed that, as in the standardised spelling assessments reported above, almost all errors (98%) were phonologically plausible.

Table 64: *Number correct for RF and comparison group in irregular word and nonword spelling (standard deviations are in parentheses)*

	RF	*Z*	Comparison group mean
Irregular words (max correct=20)	2****	-2.7	15.91(1.9)
Nonwords (max correct=40)	39	.04	38.55 (1.2)

Note: ****$p<.0001$

Phonological ability and rapid naming

The blending subtest from the standardized Athena Test battery (Paraskevopoulos et al., 1999) was used. Since this battery is for children aged up to age ten, and RF was twelve years old, more demanding phonological ability assessments were also administered. One was a spoonerisms task, adapted from the Phonological Assessment Battery (Frederickson et al., 1997) for English-speaking children (see Study 1), and one was a word reversal test adapted from a task developed by De Pessemier and Andries (2009). In the second task, children have to judge if the second of two spoken stimuli is a reversal of the first or not ((e.g., *υπολογιστής /ipoloyistis/(*computer*)–σητσιγολοπυ* /sitsiyolopi/). RF performed three practice trials for both tasks and the time needed to complete all the pairs (12 in each task) was measured with a stopwatch.

Rapid automatized naming was assessed with the picture and digit naming subtasks of the Phonological Assessment Battery (Frederickson et al., 1997) and also with a letter sound naming test devised for this study (see also case study 7.5). Results for RF and the comparison group in all the tasks are given in Table 65. RF's performance did not differ significantly from that of the comparison group except for in spoonerisms, where RF's time to complete the task was faster than the mean for the comparison group, $t(11)=1.9$, $p<.05$.

Table 65: *Scores in assessments of phonological ability and RAN for RF and the comparison group. Times recorded for the spoonerisms and word reversal tasks involve time to complete the task. Times for the RAN tasks involve time to complete naming the task stimuli (standard deviations are in parentheses)*

	RF				Comparison group mean	
	Accuracy	*Z*	Time *(secs)*	*Z*	Accuracy	Time *(secs)*
Blending (max correct = 32)	30	.00	-		30 (2.7)	-
Spoonerisms (max correct = 20)	19	.35	54*	-1.7	18 (2.9)	141 (43)
Word Reversals (max correct = 12)	7	.56	76	-1.3	6.1 (1.5)	118 (27)
RAN[a] Pictures			39	.25		38 (5.1)
RAN[a] Digits			20	-.09		21 (4.7)
RAN[a] Letter sounds			15	.38		14 (3.1)

Note=[a]Rapid automatized naming, *$p<.05$

Print exposure

Stanovich and colleagues (1997) suggested that developmental surface dyslexia may be due to lack of exposure to print, see section 3.2. for a review. This possibility in RF's case was investigated with two print exposure tests (see Study 1 for description). It was found that RF's scores for title recognition (10/25 correct) and author recognition (9/25 correct) did not differ significantly from those of the comparison group (comparison group mean correct=8.82, *SD*=3.3 for title recognition, $t=0.34$, $p>.05$; comparison group mean correct=9.5, *SD*=5.1 for author recognition $t=0.09$, $p>.05$).

Sentence-printed word matching with homophones

Sentence-printed word matching tasks with homophones included in the distractors have been considered to be a measure of lexical orthographic processing, that is, of the ability to access word recognition units in the lexical system, as well as of the integrity of these units themselves. Thus, for example, Hagiliassis et al. (2006) (also see section

3.2.) argued that homophone verification can be used as a measure of pure orthographic processing, independent of phonology. This is the case as phonology cannot contribute in the recognition of the correct spelling of a word against its phonologically identical foil. English-speaking surface dyslexics have been reported to make high rates of homophone choice in this type of task (e.g., Weekes & Coltheart, 1996; Brunsdon et al., 2005) and this has been interpreted as due to reliance on sublexical processes.

The task developed for RF involved 40 target homophones. On each trial RF was presented with a sentence spoken by the tester and a choice from among four printed stimuli. The choices comprised the target homophone, the homophonic mate of the target, a pseudohomophone of the target, and a word visually similar to the target (e.g., target homophone: μηλιά (apple tree) /milja/, homophonic mate: μιλιά (human talk) /milja/, pseudohomophone: μοιλιά /milja/, and visually similar word: φιλιά (kisses) /filja/). Results for RF and the comparison group are given in Table 66.

Table 66: *Number of choices made from the four alternatives provided in the sentence-printed word matching task for RF and comparison group (standard deviations are in parentheses)*

	RF	*Z*	Comparison group mean
Correct (max correct= 40)	28****	-2.6	38 (2)
Homophonic mate	10**	-.83	2 (2.1)
Pseudohomophone	1	-.84	0
Visually similar word	1	-.84	0.2 (0.4)

Note:** p<.01, **** p<.0001

RF's performance differed significantly from that of the comparison group, $t(11)=4.5$, $p<.0001$, $r=.80$. The majority of his errors (83%) consisted of choice of the homophonic mate of the target. Choice of the pseudohomophone of the target and the visually similar distractor represented 8% of errors each. This is in agreement with the results for English-speaking surface dyslexics in terms of the high rate of homophonic mate choice.

Visual memory

The same tasks as for the other case reports were used to assess visual memory. The results in the four visual memory tasks for RF and the comparison group are presented in Table 67. RF's performance differed significantly from that of the comparison group only for visual memory for pictures ($t(11)=2.2$, $p<.05$). In this task he performed significantly better than the comparison group.

Table 67: *Visual memory task scores for RF and the comparison group (standard deviations are in parentheses)*

	RF	*Z*	Comparison group mean
Pictures (max correct = 32)	31*	1.7	22 (3.8)
Designs (max correct = 32)	20	.08	19.7 (3.6)
Simultaneous memory (max correct = 12)	10	.99	8 (1.8)
Sequential memory (max correct = 12)	11	1.5	8 (1.7)

Letter report

Greek letters were used to develop equivalents of the tasks used by Bosse et al. (2007) to assess simultaneous multi-character processing. Both global and partial letter report were assessed (see Study 3). RF and all the comparison group children responded with letter sounds. The comparison group for the letter report tasks consisted of eight typically developing readers/spellers matched to RF in age and non-verbal ability (mean age:12;05 *SD*=0;05, range 11;09-13;06). The children were a sub-sample of the eleven children who acted as the comparison group in the other assessments reported. Table 68 gives the results.

Table 68: *Results for RF and the comparison group in the letter report tasks (standard deviations are in parentheses)*

	RF	*Z*	Comparison group mean
Global report arrays (max = 20)	0.00^{**}	-2.4	9.5 (2.5)
Global report total letters (max = 100)	59.0^{***}	-2.6	85 (4.6)
Partial report (max = 45)	40.0	.22	38.2 (1.9)
Letter identification accuracy (max=45)	45	.74	44.4 (0.74)
Letter identification (msecs)	773	.61	735 (84.2)

Note:* p<.05, ** p<.01

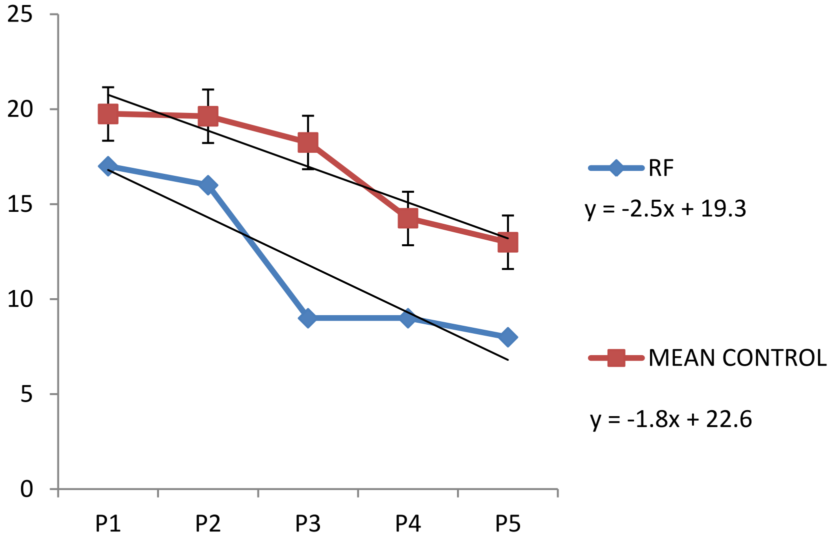
For global report, RF showed a marked impairment in the task, $t_{arrays}(8)=3.58$, p=.004,

r=.78 and $t_{total\ letters}(8)$=5.32, p=.001, r=.88. For partial report RF's performance was comparable to that of the comparison group.

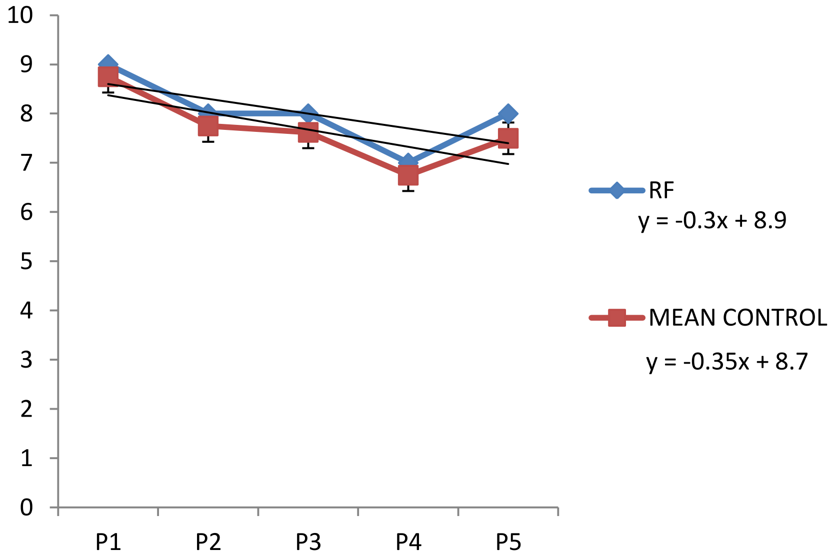
Valdois et al. (2011) used a control task of single letter identification in their study in order to investigate potential visual processing difficulties for letters. An equivalent task was devised for RF. The nine letters used in the letter report task were presented singly in the center of the computer screen for five different presentation durations (33 msec, 50 msec, 67 msec, 84 msec and 101 msec). RF and the comparison group children were asked to name them immediately they appeared. Prior to letter presentation a central fixation point appeared for 1000 msec and at the appearance of the letter a mask (13 mm high and 37 mm wide) appeared for 150 msec. The results for single letter identification are given in Table 69. RF's letter identification accuracy and naming times did not differ significantly from those of the comparison group.

For the global and partial letter report results were examined the effect of letter array position on accuracy for RF and the comparison group. The results are presented for global report in Figure 16a and for partial report in Figure 16b. The global report profile of the comparison group was characterised by a linear function, $F(1,8)$=60.08, p<.001, η^2=.88, and this was also the case for RF. At positions 1, 2 and 3, RF was significantly less accurate than the comparison children (correct Position 1 for RF=17, comparison group mean=19.75, SD=0.46; $t_{P1}(8)$=5.63, p<.0001, correct Position 2 for RF=16, comparison group mean=19.63, SD=0.51; $t_{P2}(8)$=6.58, p=.001, and correct Position 3 for RF=9, comparison group mean =18.25, SD=1.2; $t_{P3}(8)$=6.71, p=.0001). For positions 4 and 5 the difference approached significance (correct Position 4 for RF=9, comparison group mean=14.25, SD=2.8; $t_{P4}(8)$=1.77, p=.06, correct Position 5 for RF=8, comparison group mean=13 SD=2.8; $t_{P5}(8)$=1.68, p=.06).

Figure 16: *Letter report accuracy according to letter position for RF and the comparison group*



a. Global report



b. Partial report

Note: P=position

For partial report the performance of the comparison group was again characterised by a significant linear trend, $F(1,8)=22.3$, $p=.001$, $\eta^2=.74$, and RF reported letters in all positions at a level very close to that of the comparison children.

Discussion of RF's results from detailed assessments

Assessment of lexical and sublexical processes for spelling indicated that RF's spelling of nonwords was not impaired. However, for irregular words, performance was significantly worse than that of the comparison group. Analysis of RF's spelling errors showed that the majority were phonologically plausible. In the sentence-printed word matching task with homophones RF's performance differed significantly from that of the comparison group and, importantly, the majority of errors consisted of choice of the homophonic mate of the target. This is similar with the results from other studies of people with surface dyslexia (e.g., Weekes & Coltheart, 1996; Brunsdon et al., 2005; Friedmann & Lukov, 2008, see 2.3.2.1 and Introduction, Chapter 7). The findings indicate that RF has a deficit involving lexical reading and spelling processes, and that he relies on sublexical processes.

Assessment in non-literacy tasks indicated that RF did not have difficulties in phonological ability or RAN. Overall, the profile demonstrated by RF, in terms of slow word reading, poor irregular word spelling and lack of evidence of a phonological deficit, is shared with one of the two Greek speaking children reported by Douklias et al. (2009), see section 7.1.3., and with two surface dyslexic children (SD1 & SD2) described by Niolaki, Terzopoulos, and Masterson (in press). Douklias et al., as noted in the Introduction (section 7.1.3.), argued that the pattern could be associated with surface dyslexia in a transparent but also an opaque writing system.

Stanovich et al. (1997) suggested that developmental surface dyslexia may be due to lack of exposure to print in combination with a mild phonological deficit, also see section 7.1.3. This possibility was investigated in RF's case with print exposure tests, even though there was no evidence that he had a phonological deficit. There was not found any significant difference in author or title recognition scores for RF and the comparison group. Thus, it is unlikely that RF's literacy difficulties can be attributed to lack of exposure to print. Developmental surface dyslexia has also been associated with poor visual memory (Goulandris & Snowling, 1991) and a specific sequential processing deficit (Romani et al., 1999) as discussed in section 3.2. Assessments revealed that neither of these were apparent for RF.

The assessment that did indicate a deficit was a letter report task, that has been used in the past as a measure of simultaneous multi-character processing ability. RF was able to report fewer letters than children in the comparison group when tested in global report. As noted in the literature review (multi-character processing Chapter 6), poor performance in letter report has been associated in the literature with developmental surface dyslexia and surface dysgraphia (e.g., Valdois et al., 2003; Valdois et al., 2011).

RF presented with a deficit in simultaneous multi-character processing without a phonological impairment, not different from previous reports of a selective letter report deficit (Bosse et al., 2007; Lowe, 2009) and in agreement with the aforementioned case NT and with the two developmental surface dyslexic children presented by Niolaki et al. (in press).

It was noted in Chapter 6 that, at present, it is not clear exactly what the locus of a simultaneous multi-character processing deficit is. The suggestion of Dubois et al. (2010) was reviewed that it may be due to (among other possibilities) slow uptake of visual information, limited visual storage capacity, or a deficit in the spatial distribution of attention. RF's ability to identify single letters was assessed and the results did not indicate a deficit, indicating absence of any general visual processing impairment. As far as a potential imbalance in distribution of attention is concerned, it is unlikely to be the cause of poor letter report performance in RF's case since a deficit here would also have resulted in poor performance in partial report. In terms of limited visual storage capacity, there was no indication from the results of the visual memory tasks for any impairment in this regard, which might suggest that a deficit in visual memory per se could not be responsible for RF's poor performance in global report. However, the visual memory task requirements differed from those in the global report task in a number of respects. The visual memory tasks, unlike the letter report tasks, did not involve very brief stimulus displays, and responses involved recreating the test array from a set of stimuli and distractors, rather than recall. In addition, the font size was larger in the visual memory tasks than in the letter report tasks. Finally, there were fewer items in the sequential and simultaneous visual memory tasks (but not the memory for pictures and designs tasks) compared to the letter report tasks.

A speculative explanation of RF's letter report deficit might be that he was only able to establish a weak trace in visual memory with the short stimulus display times. Such a trace would be liable to fast decay, and only be able to support recall of a few letters from the test array. This could plausibly allow for adequate performance when only one letter needed to be recalled, as in the partial report task, but poor performance when the whole array needed to be recalled, as in the global report task. Observations of RF's behaviour in the global report task support this suggestion: he frequently reported two or three letters from the array and then gave up. A weak visual memory trace such as that proposed above could also plausibly impair the learning of new printed word forms, leading to a reliance on laborious sublexical decoding, as appears to be the case for RF.

Intervention study

According to the investigations carried out, the locus of RF's impairment was with lexical reading and spelling processes, as he did not exhibit an impairment in nonword reading or spelling but showed slow word reading and difficulty in spelling irregular words. Investigations also identified a deficit in letter report performance, as discussed above. For the intervention it was aimed at improving RF's letter report performance and to investigate whether any improvement might be associated with change in reading and spelling ability. In so doing the theory that simultaneous multi-character processing ability is associated with literacy skills could be tested (Nickels et al., 2010, see also relevant argument in Introduction Chapter 7).

A pragmatic reason for targeting letter report performance was that slow reading speed was put forward as the main literacy-related concern of RF and his family and it was reasoned that a simultaneous multi-character processing deficit would be particularly detrimental to speed of reading in Greek, since the vast majority of words are multisyllabic. Based on the theory of Ans et al. (1998), presented in Chapter 6, an improvement in simultaneous multi-character processing would allow for the processing of larger orthographic units and therefore should lead to faster reading due to reduction in reliance on slow serial sublexical processing. It was also aimed to look at the possible association of any improvement in letter report with an increase in RF's word reading speed and accuracy. The speculative account of RF's deficit in letter report outlined above was in terms of a weak or degraded visual memory trace when stimulus presentation is brief. The intervention devised was based on the general notion that practice with arrays of increasing size might lead to a gradual increase in visual memory capacity.

Method

Pre-intervention assessment

Two pre-intervention baseline assessments of letter report were carried out, two weeks apart. Results of Baseline 1 are reported in the *Detailed assessments* section above. On this occasion, for global report RF scored 0/20 for arrays correct, and 59/100 for total letters correct. At Baseline 2, for global report RF scored 0/20 for arrays correct and 60/100 for total letters correct. The intervention procedure is presented next.

Letter report intervention procedure

The intervention involved repeated practice at reporting arrays of increasing length. Three sets of arrays were devised, Set 1 consisted of 195 two- to four-letter arrays, Set 2 195 three- to five-letter arrays, and Set 3 104 four- and five-letter arrays. The procedure for the presentation of the arrays was exactly as described for the global report task in the *Detailed assessments* section. Practice sessions lasted approximately 10 minutes and took place each day (when possible, see below). During each practice session there were two rest periods for Set 1 and Set 2 (with 65 arrays before rest), and one rest period for Set 3 (with 52 arrays before rest).

Intervention lasted nine weeks. Target accuracy was fixed at 95%+ for Set 1, 95%+ for Set 2 and 50%+ for Set 3. RF needed six practice sessions to reach target accuracy for Set 1, ten for Set 2 and eight for Set 3. When target accuracy had been achieved for Set 2 RF spent a week without practice, in order to reduce task fatigue. Target accuracy was fixed at 50%+ for Set 3 since RF found the task very difficult and a higher target could possibly frustrate him. RF spent two weeks on each set and during these two weeks he practiced each set. Practice did not take place every day as if he had a test at school he could not devote time to the task. In order to minimize the effect of repetitive exposure to the same stimuli, arrays used in training and testing sessions were not the same. Table 69 gives a breakdown of the level of accuracy RF achieved for each array length at the end of practice with each set.

Table 69: *Number of practice sessions per set and score (percent correct) achieved by RF for strings of different lengths*

	Total sessions	2Letters	3Letters	4Letters	5Letters
Set 1	*6*	100	100	89.8	-
Set 2	*10*	-	100	95.3	36.3
Set 3	*8*	-	-	100	65

Results

Global and partial letter report accuracy

Post-intervention assessments were conducted at three time points: immediately at the end of intervention (Time 1), four months after it ended (Time 2) and eight months after it ended (Time 3). The results are given in Table 70. At pre-intervention testing, as reported previously, RF's scores for global report were significantly worse than those of the comparison group children. Inspection of Table 70 reveals an improvement following intervention, such that accuracy was no longer significantly different from that of the comparison children, either for number of arrays or total letters correct.

Analyses of the extent of improvement in RF's scores were carried out, which involved comparison of his performance at Baseline 1 versus Time 1 versus Time 2 versus Time 3. McNemar's tests were used to analyse the data. The results indicated that between baseline and Time 1 there was a significant increase both for arrays correct, χ^2=9.1, p=.001 and for total letters correct, χ^2=30.03, p<.0001, whereas between Time 1 and Time 2 and between Time 2 and Time 3 there were no further significant changes (p=1). This indicates that there was improvement in RF's global report performance following the intervention, but that there was no further improvement (or decrease in performance) once intervention stopped.

Four children from the comparison group who were tested before RF's intervention were re-assessed at the same time that RF was given the final post-intervention assessment (at Time 3). This was in order to look for general maturation effects in letter report in the typically developing children. A summary of the results is given in Table 70. Related t-tests were used to analyse the scores for global and partial report and revealed that there were no significant differences for the comparison children. There was therefore no indication of general maturation effects in letter report performance in children of comparable age and non-verbal ability to RF over the relevant time period.

Table 70: *Pre- and post-intervention performance in the letter report task for RF and the comparison group (standard deviations are in parentheses)*

	Pre-intervention		Post-intervention			Comp. Group mean	
	B1	B2	Time 1	Time 2	Time 3	Pre-Int	Time 3
Total Arrays (max = 20)	0*	0*	11	10	12	8.5(2.6)	7.8 (1.8)
Total Letters (max = 100)	59**	60**	91	91	90	84.5(5.0)	86 (2.8)
Partial report (max = 45)	40	-	41	42	43	38.7(0.5)	40 (3.1)

Note= B1= Baseline 1, B2= Baseline 2, * p<.05, ** p<.01, *** p<.001, **** p<.0001.

Literacy assessments

Reading and spelling tasks were re-administered to RF and the comparison group. As for the letter report tasks, post-intervention assessments were conducted at three time points: immediately at the end of intervention (Time 1), four months after it ended (Time 2) and eight months after it ended (Time 3). A summary of the results is given in Table 71. At pre-intervention testing RF's scores for word reading accuracy and latency were significantly different from those of the comparison group. Inspection of Table 71 reveals an improvement in RF's single word reading accuracy and latency following intervention, such that scores were no longer significantly different from those of the comparison group children. Pre-intervention assessment had also indicated that RF's text reading speed was slow and his spelling of irregular words was impaired. Post-intervention testing revealed that scores for both of these continued to be significantly different from those of the comparison group (at Time 3 $t_{text\ reading\ rate}(4)=9.52$, $p<.001$, $t_{irregular\ word\ spelling}(4)=9.81$, $p<.001$).

As for the letter report results, four children from the comparison group tested before intervention were re-assessed at the same time that RF was given the final post-intervention assessment in order to look for general maturation effects. A summary of the results is given in Table 70. Related t-tests were carried out and did not indicate significant differences for any of the literacy measures between pre-intervention and Time 3 for these children.

Table 71: *Pre and post-intervention performance in reading and spelling assessments for RF and the comparison group (numbers in bold are standard scores, standard deviations are in parentheses)*

	Pre-intervention	Post-intervention			Comp. group mean	
		T1	T2	T3	Pre-int.	T3
Standardised measures						
Reading comprehension[a]	**108**	**108**	**113**	**115**	**119 (1.1)**	**119 (1.2)**
Text reading rate[a]	**67****	**68****	**76****	**76****	**125 (4.8)**	**125 (4.6)**
Experimental measures						
Single word reading accuracy (max correct= 53) [a]	42***	50	50	52	51.7 (0.95)	52.5 (0.57)
Single word reading latency (msecs)[a]	1719**	1039	1228	1092	887 (235)	756 (132)
Nonword reading accuracy (max correct = 24)[a]	16	17	19	23	19.5 (1.9)	18 (4.1)
Nonword reading latency (msecs)[a]	1802	1105	1230	1084	1112 (334)	1007 (212)
Irregular word spelling[b] (max correct = 20)	2****	-	7***	9***	18 (0.82)	18 (1.9)
Nonword spelling[b] (max correct = 40)	39	-	39	40	39 (0.96)	40 (0.50)

Note:[α] Reading Test Alpha (Panteliadou & Antoniou, 2007), [b] Loizidou-Ieridou et al. (2009), * p<.05, **p<.01, ***p<.001, ****p<.0001

Comparison of change in RF's word reading accuracy and latency between pre-intervention-Time 1, and Time 2-Time 3

Failure to include a double baseline assessment for the reading and spelling tasks meant that the improvement found in RF's word reading accuracy and latency may have been due to general maturation or test-retest effects. Since the time lapse of four months between Baseline 1 and Time 1 and between T2 and T3 testing was equivalent then it was possible to compare change in performance for these two time periods – a larger difference in the former would be an indication that the intervention was responsible for the improvement[13].

Two sets of comparisons were made, one for latencies and one for accuracy. A paired sample t-test was conducted to see whether the difference for latencies was significantly different across the two time periods (mean latency Time 1- Baseline 1=686, *SD*=582, mean latency Time 3-Time 2=129, *SD*=296). The result revealed that the difference in latencies between Baseline 1 and Time 1 was significantly greater than that between Time 2 and Time 3, $t(38)= 5.3$, $p<.0001$. McNemar's tests were used to analyse the significance of change in accuracy across Baseline 1-Time 1 and Time 2-Time 3. The change Baseline 1-Time 1 was highly significant (p=.008), while the change Time 2-Time 3 was not significant (p=1).

Summary of intervention findings

The assessments conducted after the intervention revealed significant improvement in global report for arrays and total letters, and improvement was also observed in reading accuracy and latency for single words. When RF was asked if he had noted any change in his reading after the intervention he reported that he now found it easier to read subtitles on the television screen for foreign language programs.

Interim summary

The case study involved a monolingual Greek child with reading and spelling difficulties. RF exhibited a deficit in reading, both in terms of accuracy and reading rate, in a standardised test. Efficiency of lexical and sublexical reading and spelling processes was assessed through word and nonword reading and spelling tasks. RF showed slower reading of words and less accurate spelling of irregular words than an

[13] I am grateful to one of the anonymous reviewers in the *Cognitive Neuropsychology* journal for this suggestion.

age matched comparison group. However, reading and spelling of nonwords was not impaired. Qualitative analysis of spelling errors revealed that the majority of these were phonologically appropriate. Assessment of phonological ability, RAN and visual memory did not reveal difficulties.

Douklias et al. (see argument in Section 7.1.3.) argued that since, for reading, Greek does not have irregular words; developmental surface dyslexia is manifested in that language by slow word reading and poor irregular word spelling, in the absence of a severe phonological deficit. RF showed this pattern, and in addition the predominance of phonologically appropriate misspellings and high rate of homophone choice in a printed word-sentence matching task reinforced the picture of a selective lexical processing deficit. Unlike the two surface dyslexic cases in the study of Douklias et al. RF did not show an impairment of RAN. Further research is needed to understand why RAN is associated with the surface dyslexia profile in some cases and not others.

Past research has indicated that lexical processing deficits may be associated with a deficit of simultaneous multi-character report, and particularly for global report (e.g., Valdois et al., 2011, see Chapter 6 for a review). When global report was assessed with RF, performance was found to be significantly less accurate than that of a typically developing comparison group. In contrast, partial report performance appeared to be unimpaired. Similar was the result for NT, the case study presented on page 225. NT had a difficulty in letter report but not in PA, RAN or visual memory. Table 72 presents RF and NT’s performance in cognitive tasks in Greek language in order facilitate comparisons.

Table 72: *Performance of NT and RF in phonological ability, RAN, visual memory and letter report in Greek language*

	NT	RF
Blending (max correct = 32)	26	30
Spoonerisms (max correct = 20)	16	19
RAN[a] Pictures	60	39
RAN[a] Digits	20	20
Pictures (max correct = 32)	18	31*
Designs (max correct = 32)	15	20
Simultaneous memory (max correct = 12)	5	10
Sequential memory (max correct = 12)	5	11
Global report arrays (max = 20)	1*	0.00**
Global report total letters (max = 100)	58**	59.0***
Partial report (max = 45)	28	40.0

P values refer to comparisons between RF and same age control children, and NT and same age comparison group.

Although NT and RF did not share the same difficulties, as NT had mixed dysgraphia and RF had developmental phonological dyslexia, they both found it difficult to report arrays of letters presented simultaneously on the computer screen. Another point one should note is that they did not have any difficulty in the partial report of the same task. Bosse and Valdois (2003) also reported, for reading, that children with characteristics of mixed dyslexia had a simultaneous multi-character processing disorder in absence of a phonological ability disorder. This is in agreement with NT's performance in multi-letter simultaneous processing although NT had mixed dysgraphia and not dyslexia. Further discussion on case studies presented and possible explanations of their difficulties in relation to group studies 1, 2 and 3 is included in the *General Discussion* section.

Chapter 8

8. General Discussion

8.1. Introduction

To summarise, findings from group studies with typically developing readers and spellers help to increase our understanding of the cognitive architecture of spelling. It has been argued that intervention studies allow for control of confounding variables. Intervention studies were conducted as a means of providing confirmatory evidence for findings from the group studies. The aim of the studies conducted was twofold; on the one hand they attempted to find factors that are associated with spelling in bilingual English- and Greek-speaking children, and on the other hand to investigate characteristics of children with atypical spelling performance and the effectiveness of training programmes. Prior research carried out with bilingual children has indicated that literacy skills transfer from one language to another (Koda, 2008; Mumtaz & Humphreys, 2002; Figuerdo, 2006, Introduction to Study 1 and 2). Research carried out with children and adults with literacy difficulties has suggested that the underlying cause of literacy difficulties is not unitary (c.f. Brunsdon et al. 2002; 2005; Nickels et al. 2008a, 2008b; Broom & Doctor, 1995a, 1995b; Bosse et al., 2007, Introduction, Study 4). The contribution of the studies derives from the fact that case studies with multilingual participants with literacy difficulties and in the Greek language are sparse. Firstly, the findings from the group studies with typical spellers will be discussed and then the case reports will be summarized.

8.1.1. *Identifying factors that predict spelling performance*

For monolingual younger English participants, visual memory, as well as PA, were significant predictors of spelling performance. This was found in Study 1 and Study 2. Results from the monolingual younger English-speaking children are not consistent with the findings of Caravolas et al. (2001) who did not detect a significant association between visual memory and spelling performance. However, this discrepancy could be attributed to the different ages of the participants in the two studies, or to differences in tasks used. In the Caravolas et al. (2001) study children were aged 4 to 8, whilst in the present study they were aged 6 to 9 years (see also section 3.2 for a review). Consequently, phonological ability may be a strong predictor of monolingual English children's spelling at the early years of instruction, but with further experience of the opaque English orthography, visual memory may come to play a more significant role, as for the older monolingual English children in Study 1 only visual memory predicted spelling performance.

Giles and Terrell (1997) in their study of poor spellers with mean age 14;03, concluded that visual sequential memory (employing nameable and non-nameable pictures) did not have a significant role in spelling for these children (for a description of the study see section 3.2.). Again, differences in age of participants between the Giles and Terrell study and the present one, as well as differences in tasks used could have caused the discrepancy in findings. However, findings from the monolingual younger children are in agreement with Masterson et al. (2008) who found a strong effect of visual memory in spelling of monolingual English six-year-old children. These children's spelling performance was predicted by scores in a phonological ability task and visual memory. Findings from the younger children in Study 1 were replicated by a different group of children with the same age and spelling characteristics in Study 2a.

Older (nine-year-old) children's English spelling scores were predicted only by visual memory and not PA and this was consistent with the results of Study 3. In this study children's spelling performance was predicted by a task tapping simultaneous multi-character processing and not PA. Children in the two studies (1 and 3) were comparable in age and spelling skill.

For monolingual younger Greek speaking children a similar pattern to the younger monolingual English children emerged as for the younger Greek participants both PA and visual memory predicted children's spelling skill. The effect of PA is consistent with other studies investigating Greek spelling of monolingual children (such as Tafa & Manolitsis, 2008; Masterson et al., 2008, see section 3.2 for a review). In Study 2a, for a different group of children assessed in a different task taping phonological ability (blending) only PA and not visual memory was significantly associated with children's spelling performance.

Study 1, older (aged nine) Greek speaking children's spelling performance was predicted by the same variables, visual memory and PA. The only difference from the younger participants was that the direction of associations changed as scores in visual memory contributed more variance in Greek spelling than scores in PA. This result does not contradict findings from Study 3 where children of comparable age and spelling skill where found to rely on both lexically and sublexically related variables (both simultaneous letter report and PA predicted the children's spelling). It is worth mentioning that, in agreement with Study 1 (older Greek participants), in Study 3 simultaneous letter report was more significantly associated with spelling ($p<.01$) than PA ($p<.05$). The findings could suggest that for children learning a transparent orthography after the early stages of literacy acquisition, PA loses its predictive validity (Tafa & Manolitsis, 2008; Nikolopoulos et al. 2006) due to ceiling effects. However, this was not the case for the monolingual Greek children in the studies presented. Thus it seems that for languages less transparent in spelling, such as Greek, lexical processes are also important.

A qualitative analysis of the spelling errors in the different groups in Study 1 revealed that the vast majority (91%) of the errors of the monolingual Greek group were phonologically appropriate. While this was also the predominant type of error made by the monolingual English group, the percentage of such errors was lower. Stimulus-related analyses indicated that results are in line with findings reported by Spencer (2007, also see section 2.4.1. & 3.3) for monolingual English speaking children aged 6 to 10. The results indicate that children of this age use both lexical and sublexical processes for spelling in English. In contrast, in the older English monolingual children in Study 1) spelling was only predicted by frequency and not LTPG, indicating, as in the analyses of the child-related variables, that lexical variables become more important with age. For the older Greek monolingual children, the results based on the stimulus-related analyses indicated that children rely on both lexical and sublexical processes. Results are also in line with findings reported by Loizidou et al. (2009) for monolingual Greek speaking children aged 6 to 10 and Giannouli and Harris (1999) (see section 2.4.1.& 3.3. for a review).

Study 3, examining the effect of simultaneous multi-letter processing and PA, confirmed that for monolingual English speaking children lexical variables appear to play a more imprtant role in spelling. The outcome is consistent with results of Bosse and Valdois (2009, see also Chapter 6) who in a cross-sectional study found that across grades letter report was a strong predictor of irregular word reading indicating that multi-letter processing is a significant component of particularly lexical processes for reading. In the present study partial correlations conducted indicated that letter report contributes to spelling skill independently from PA. For Greek monolingual children the results were similar. This indicates that despite the difference in transparency of Greek and English, lexical processes seem to also play a significant role in Greek spelling, at least for children of the age range targeted in the present study.

In summary, the findings suggest that the DR theory is an appropriate framework for identifying processes related to spelling skill. The model, as indicated by research findings from the monolingual English and Greek children in the current studies, can provide a coherent interpretation of findings in studies investigating the processes involved in spelling. Findings indicate that both lexical and sublexical processes accommodated in the DR model are important during spelling not only for the English but also for the Greek writing system. It also seems that lexical processes are even more important for spelling at least for older spellers of these particular monolingual groups. The spelling of both orthographies is unreliable, and therefore application of only sublexical processes would have a detrimental effect on spelling. However, characteristics of each writing system seem to affect the spelling processes.

8.1.2. *Transfer effects in spelling*

The findings are in agreement with studies which indicated that cognitive processes are transferred from one language to another (Liow & Lau, 2006; Holm & Dodd, 1996; Xuereb, 2009; Sun-Alperin & Wang, 2011, presented in section 2.5), including that of Mumtaz and Humphreys (2001, 2002). Although the latter study investigated reading, and the present study investigated spelling, both sets of findings (as well as those of a number of other studies) indicate that levels of exposure to a transparent orthography can influence the use of lexical and sublexical processes in opaque English (Holm & Dodd, 1996; Mumtaz & Humphreys, 2002).

For the bilingual children the overall findings indicated that children with low Greek literacy ability rely more on lexical procedures for spelling in English and children with strong Greek literacy ability rely more on sublexical processes for spelling. This was confirmed in the longitudinal analyses. The longitudinal data indicated that visual memory was the strongest predictor of English spelling for the children with low experience in Greek literacy at both time points; whereas for the children with a higher level of exposure to Greek, phonological ability was the concurrent and longitudinal predictor of English spelling performance. The result is also consistent with the cross-sectional analyses as the younger bilingual (seven-year-old) children appeared to rely more on sublexical variables and the older bilingual (nine-year-old) children, both lexical and sublexical variables for spelling. Finally, they are consistent with results of Study 3 where both PA and letter report predicted these children's English spelling performance. Bilingual children also showed better performance in tasks tapping sublexical skills such as reading of non-words in contrast to monolingual children. This is in agreement with Da Fontoura and Siegel (1995, see also section 7.1.2.) who reported that bilingual English- and Portuguese-speaking reading disabled children had higher scores in an English pseudoword reading task and in spelling in comparison to a group of English monolingual disabled readers. Findings are also in agreement with Figueredo (2006) who reported that positive transfer will occur when common strategies are used, such as phonological ability. This does seem to have been the case, since for the strong Greek literacy group phonological ability was the strongest predictor of their English spelling.

The results of the qualitative analyses of the children's spelling errors are in favour of transfer effects in spelling. The strong Greek bilingual group made more phonologically appropriate spelling errors than the weak Greek bilingual group at both time points, indicating greater involvement of phonological or sublexical processes in spelling in the case of the former group, in agreement with the Greek monolingual children's performance.

The analyses of stimulus-related variables did not reveal the same dissociation between lexical and sublexical processing variables for bilingual children participating in the longitudinal and the cross-sectional analyses, as both frequency and LTPG predicted children's spelling performance. The findings are in line with monolingual children's performance. It is worth mentioning that although for English monolingual older children only printed frequency predicted the children's spelling, for bilingual children matched in spelling skill both frequency and least transparent phonographeme probability predicted the children's spellings. The result provides further support for the flexibility of developing cognitive processes, in agreement with the findings of other cross-linguistic studies (see for example, Perfetti et al., 2007, section 2.5).

In summary, the results support predictions made that we would observe evidence of differential reliance on lexical and sublexical processes for spelling in English in children according to their level of proficiency in transparent Greek. The field of language transfer effects is a relatively new one (Koda, 2008, see section 3.4.1.). This line of enquiry would seem to be potentially productive for increasing our knowledge of the acquisition of literacy in biliterate and bilingual children and also, more generally, for increasing our knowledge of the organization of linguistic and cognitive processing systems (Ellis, 2005). Additionally, the results from the present study are in agreement with the DR model developed for both monolingual and bilingual children (c.f. Barry, 1994; Luelsdorff & Eyland, 1991; Klein & Doctor, 2003, see sections 2.3., 2.5 & 7.1.1.). The latter two models, for bilingual children, contain both lexical and sublexical routes (oral and written spelling) for each language. The two linguistic codes utilize both lexical and sublexical strategies in order to achieve correct spelling. This in particular is in agreement with findings deriving from the present research as both lexical and sublexical spelling processes are important for bilingual speakers in order to spell accurately English. Reliance on each route is moderated by the transparency of the linguistic code and language dominance.

Interim summary

Overall, partial correlations conducted indicated that even after controlling for the effect of age visual memory was a significant component for English and Greek older children's spelling performance, whereas for younger children's spelling performance PA was also a significant contributor. This indicated that spelling processes do not differ among languages that are different in orthographic depth.

For bilingual younger children PA is important for those with stronger Greek input but not for those with weak Greek literacy awareness. For older bilingual children after controlling for age the most important variable that emerged was vocabulary. This is to be expected as these children have to learn the language, so they will put more effort in this domain rather than PA or visual memory. Maybe if we assess this group of children at an older age visual memory might be more important than vocabulary.

8.1.3. *Characteristics of case studies*

Case studies of five children with reading and spelling difficulties were also reported and in agreement with predictions made, children were found to experience the same difficulties in both Greek and English. This is in agreement with Masterson et al. (1985) and Geva (2000) who claims that a deficit in literacy development will be apparent in both languages (as was also noted in section 7.1.2.). It has also been shown that the properties of individual languages determine the characteristics of literacy difficulties (see for example the result of the intervention for LK where his Greek and English nonword reading and phonological ability improved dramatically, perhaps due to transfer of reltively easily-acquired sublexical skills from Greek to English spelling processes). For all the multiliterate children (LK, RI & NT) spelling performance was significantly impaired and their difficulty was manifested in both orthographies. RI made many non-phonological appropriate errors in Greek which is not the usual type of error for a transparent orthography (Protopapas et al., 2010, 2013; Nikolopoulos et al., 2003, see section 2.2). This result corroborates Doctor and Klein (1992, see section 7.1.1.) who found that their case study had profound difficulty in Afrikaans in contrast to English, although Afrikaans is considered to be a transparent orthography. However, this may not be the case for biliterates who use very different writing systems (see, for example, Wydell & Kondo, 2003, section 7.1.3.).

Looking now at each individual case, LK, a seven-year-old trilingual boy literate in Greek and English, had spelling difficulties in both languages in which he was literate. Phonological ability in Greek and English seemed to be underdeveloped. Assessment of RAN did not indicate a deficit. However, visual memory for abstract designs and visual sequential memory were impaired (see also Table 73 for a comparison among the five cases reported).

These results are similar to those observed for RI. RI was also an emergent trilingual literate in Greek and English. He had spelling difficulties in irregular words and nonwords. RI's blending in Greek was impaired, though not in English, and his scores in spoonerisms were poor in both languages. He did not seem to have a RAN deficit but visual memory for sequentially presented characters was impaired. Unlike LK, he did not exhibit a visual memory for designs deficit. Findings from LK and RI are consistent with the phonological core deficit hypothesis (Stanovich et al., 1997, see section 3.2.) and Snowling (2000) in relation to phonological difficulties but also with Goulandris and Snowling (1991) in terms of a visual memory and visual sequential memory deficit for LK, and in terms of a visual sequential memory deficit for RI (Romani et al., 1999).

ED shows a different profile although she also exhibited difficulties in spelling in English for irregular words and non-words. ED experienced difficulties in both PA and RAN tasks. Visual memory for designs and for sequentially presented characters was unimpaired, but she exhibited difficulty with visual memory for pictures. ED has the characteristics of a double-deficit described by Bowers and Wolf (1993), also see section 3.2. However, among the five case studied a single RAN deficit (without PA difficulties) was not observed. We might have expected, for a transparent orthography like Greek, a more pronounced role for RAN according to previous research (Georgiou et al., 2012a; Lander & Wimmer, 2008). Instead, assessments of phonological ability, visual sequential memory and letter report were those that revealed a deficit in the children with spelling difficulties in the present thesis.

NT was also a ten-year-old trilingual child; unlike the previous cases she only exhibited a spelling deficit in both exception and nonword spelling. She did not have any deficit in PA, RAN and visual memory tasks but she was deeply impaired in letter report tasks in both languages. She had the characteristics of a Type-B speller as described by Frith (1980) and in agreement with Lowe et al. (under review) and Bosse et al. (2007) she had a selective deficit in multi-character processing tasks. Unlike the core phonological deficit ("ibid.") she did not have a phonological deficit. It is important to note that all multiliterate children exhibited similar deficits in both orthographies in which they are literate.

RF the monolingual Greek speaking case study reported, like NT, did not show any deficit in PA, RAN and visual memory. However, his performance in letter report tasks was deeply impaired. RF has the characteristics of a surface dyslexic and dysgraphic for a transparent orthography as described by Douklias et al. (2009). Similar, finding derived from a group study conducted by Niolaki et al. (in press). In this study the two children identified as surface dyslexics had a single letter report deficit.

Although RF's global report performance was impaired, partial report appeared to be unimpaired. As noted in the literature review Chapter 6, Valdois et al. (2011) previously reported this dissociation in the case of Martial, who had mixed dyslexia and surface dysgraphia. However, the researchers concluded that Martial's performance was atypical in the partial report task when they examined accuracy according letter position in the test array. Investigation of RF's performance according to array position did not reveal atypical performance in partial report.

NT also had impairment only in global report for both languages and not in partial report. However, a closer inspection of position performance indicated a right side bias (more profound for Greek) in comparison to control's performance. Similar performance in partial report was reported by Valdois et al. (2011). This indicates that NT was atypical for both global and partial report. However, her ability to name letters, numbers and pictures was intact (similar to case RF), suggesting that her letter report deficit can cot be attributed to her ability to retrieve phonological codes from long term memory. However, the same caveats as the ones reported for RF (related to differences between visual memory and letter report tasks) also hold for NT.

Overall, the findings from case studies indicate that profiles of dysgraphia and dyslexia (phonological, mixed and surface) can be found among multilingual and monolingual children, in agreement with previous findings of Castles and Coltheart, (1993), Manis et al. (1996) and Stanovich et al. (1997). In addition, there seem to be a range of difficulties associated with spelling difficulty. Inspection of Table 73 shows that a significant dissociation observed in the case studies is the one between PA and letter report. This result is also consistent with the group study as letter report was found to be associated with spelling performance for typically developing children in Study 3.

Table 73: *Summary of results for the five case studies in PA, RAN, visual memory and in letter report tasks*

	LK	RI	ED	NT	RF
English measures					
Blending	ns	ns	sig	ns	-
Spoonerism	sig	sig	sig	ns	-
RAN Pictures	ns	ns	sig	ns	-
RAN Digits	ns	ns	sig	ns	-
Global report arrays	-	ns	ns	sig	-
Global report letters	-	ns	ns	sig	-
Partial report	-	ns	ns	ns	-
Greek measures					
Blending	sig	sig	-	ns	ns
Spoonerism	sig	sig	-	ns	ns
RAN Pictures	ns	ns	-	ns	ns
RAN Digits	ns	ns	-	ns	ns
Global report arrays	-	ns	-	sig	sig
Global report letters	-	ns	-	sig	sig
Partial report	-	ns	-	ns	ns
Visual Memory Pictures	ns	ns	sig	ns	ns
Visual Memory Designs	sig	ns	ns	ns	ns
Visual Memory Simultaneous	ns	ns	ns	ns	ns
Visual Memory Sequential	sig	sig	ns	ns	ns

8.1.4. *Effectiveness of interventions employed*

Different training programmes were devised according to the spelling deficit observed. Intervention case studies with multilingual and Greek speaking children are sparse. LK, although he had had more than two terms of formal literacy lessons targeting phonic skills and letter-sounds, could not write any novel items and his knowledge of sound-letter correspondences was minimal. Based on this a *sublexical* training programme was devised. The training involved the explicit teaching of phoneme-grapheme correspondences and phonological skills. LK's *sublexical* spelling processes showed improvement, especially for spelling in Greek and the change was shown to be sustained at delayed post-testing four months after the programme ceased. The advantage for spelling nonwords in Greek that we observed might have to do with the characteristics of the Greek writing system (being more transparent than English), or with the fact that LK attended a Greek medium school where children spoke more Greek than English. The effect of the training appeared to generalize to reading, in agreement with previous findings from single case intervention studies involving both lexical and sublexical training techniques (Kohnen et al., 2008a, 2008b; Brunsdon et al., 2005, see Introduction Study 4). Conrad (2008) in a teaching study with Grade 2 children (mean age: 7;07 years) also found that training in spelling improved reading skill whereas the opposite was not observed. Conrad concludes that orthographic representations are better supported via teaching of spelling than reading. Kohnen and Nickels (2010) also noted that in remediation research there have not been reported training studies on reading where generalization to spelling improvement was observed, whereas the opposite has been reported. Therefore, they argue that intervention should target spelling in cases where difficulties are observed in both reading and spelling.

RI also exhibited difficulties in irregular and nonword spelling and the vast majority of his spelling errors were non-phonologically appropriate. RI could not spell all the letters in a cluster or in a combination, so a sublexical training programme was given, as for LK. RI did not show the same improvement in spelling and reading of both orthographies as LK. An improvement for Greek single word reading was observed but the result was still significantly different from the comparison children. The intervention resulted in a slight improvement in nonword spelling in Greek. Torgesen (2002) concluded that a substantial proportion of children were not able to reach average reading skill, even after the conclusion of intervention. He calculated that 12-18% belong to this category. A similar conclusion was reached by O'Connor (2000) who claims that support must be continuous and Manis et al. (1993), see also section 7.1.3. for a review.

ED was found to have poor non-word and irregular word spelling and reading in English, indicating difficutly with both lexical and sublexical processes. ED took part in a training targeting sublexical processes, as it was aimed to strengthen her sublexical skills. According to Kohnen and Nickels (2010) when a child has difficulties with both routes it is easier for the child to remember parts of the word and awareness of the parts will also help the child at a later time to build a correct entry in the orthographic lexicon. However, sublexical training did not result in improvement and a second training programme was administered targeting lexical processes.

The lexical training resulted in significant improvement in spelling for targeted words, and also for untrained items. Interventions involving repeated exposure to correct spellings using flashcard techniques and delayed copying have been found to be effective, presumably because they lead to strengthening of orthographic representations (e.g., Rapp & Kane, 2002 for evidence from acquired dysgraphia; Brunsdon et al., 2005 & Kohnen et al., 2008b for evidence from developmental dysgraphia, also see Introduction section 7.1.4.). ED's spelling of nonwords was also observed to improve slightly. Unlike ED's improvement in irregular word and nonword spelling, her nonword reading did not improve. Further research investigating transfer effects of training will be informative.

Overall, for LK, RI and ED, training produced improvement in standardised spelling assessments. Particularly, for LK and RI improvement was observed in both languages in which they were literate. For ED and RI, on the other hand, although the sublexical training resulted in some improvement on the standardized spelling assessment, it was not effective in improving sublexical reading and spelling. This discrepancy in comparison to LK's response could relate to the fact that LK did not possess any representations of phoneme-grapheme correspondences, whereas RI and ED did. Consequently, for LK training of phoneme-grapheme correspondences was enough to trigger a change. The same training did not suffice for ED and RI. Perhaps incorrect PGCs caused interference with the new learning. In RI's case although the focus was on clusters and not single graphemes still the training was not effective to substantially improve nonword reading and spelling. Based on the lack of effectiveness for ED a second training was planned targeting lexical processes and this was found to be substantially successful.

Kohnen et al. (2008b, 2010, see also Introduction- Chapter 7) also 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. Like ED, RI did not show improvement following the sublexical intervention even though the sublexical intervention targeted only sound-to-letter correpondences that he had difficulty with. This might indicate that when sublexical processes are severely compromised (RI mainly made non-phonological appropriate errors not only for English (88%) but also for Greek (77%), this type of error for Greek is not the usual one even for dyslexics (Protopapas et al. 2010; 2013, as discussed in section 2.2) training with a lexical rather than a sublexical focus may be more effective (cf. Brunsdon et al., 2002). Another possible explanation for the lack of effectiveness of sublexical intervention for ED and RI might have to do with the duration of the intervention. Brunsdon et al.'s (2002b) successful sublexical intervention lasted four and a half months whereas ED and RI's intervention lasted nine weeks. If the intervention was of longer duration more improvement may have been observed.

NT had mixed dysgraphia in both languages in which she was literate and a training programme targeting her lexical skills was devised. She also exhibited low levels of receptive vocabulary for English and Greek, and analysis of the gains made during intervention revealed that greater improvement was observed for known target words than unknown words for both languages. This is consistent with the findings of Ouellette (2010), see section 3.2. Teaching the meanings of the words targeted for intervention was incorporated into the programme in the present study. However, the difference in spelling accuracy between words known prior to intervention and those taught at the time of intervention may indicate that it would be helpful in future studies to give instruction in meaning for unknown words prior to the work on spelling accuracy. Follow-up testing for retention of the meanings of taught words was not carried out, although there is some indication that the intervention was effective here too from the post-intervention assessment of receptive vocabulary. Further research on the effects of knowledge of the meaning of words in studies of intervention for literacy difficulties seems important. Like the result of ED, for NT also the intervention targeting the lexical route seemed to be very successful for spelling as gains for both children's spelling was sustained when tested four months later. It seems that providing the child with spelling specific strategies (flash card and visual imagery) and many encounters with the misspelt item, and activities that strengthen the connections between phonology, orthography and semantics is very important for improvement in this specific literacy component. Specifically, Rapp and Kane (2002) mention that, by copying the words, the word's orthographic forms in long term memory become stronger.

For RF an intervention that targeted his letter report deficit was designed. The results of the intervention indicated that the letter report deficit was associated with RF's literacy difficulty. The improvement in letter report was observed immediately following the intervention, and the improvement was sustained, as demonstrated by testing four and eight months later. A significant improvement in word reading accuracy and latency was also found, and this improvement was found to be sustained in the follow-up assessments. Previous interventions for slow reading speed (e.g., Judica et al., 2002; Hayes et al., 2006) have included a reduction in presentation time of words over time, with the aim of reducing reliance on time-consuming sublexical processes. It may be that training in letter report and presentation-time reduction both bring about a change to use of larger processing units. It will be informative to compare the effects of different types of training in future studies.

Although a small improvement in text reading rate was observed in the standardised reading test following intervention, it was not a significant gain. The improvement in single word reading latencies may need to be more marked than that shown by RF in the present study in order to produce notable gains in speed of reading text. It is plausible that change in irregular word spelling accuracy is observed some time after improvement in letter report, since presumably the establishment of lexical representations necessary for accurate irregular word spelling will be a slow, incremental process. Indeed at the eight-month follow-up assessment RF showed continued gains in spelling irregular words. However, this improvement did not produce spelling performance on a par with that of comparison children. Previous training studies with surface dysgraphic children involving repeated presentation of words with flashcards and use of mnemonic spelling techniques have been effective in improving spelling performance with irregular words (e.g., Brunsdon et al., 2005, see section 7.1.4.). This was also observed in the two case studies reported ED and NT. For the moment, it can be said that the intervention appeared to bring about an increase in word reading speed and accuracy, and reading speed was reported as significantly problematic for RF prior to the intervention.

Next will be considered how RF's improvement in letter report may have come about. Of the explanations reviewed for a deficit in letter report performance, slow uptake of letter information and imbalance in the distribution of spatial attention do not seem plausible candidates in RF's case, since deficits in either of these would be likely to have had a detrimental impact on partial report performance and evidence of a deficit in partial report was not found. Instead RF's difficulty may be better explained by a weak or degraded visual memory trace under conditions of brief exposure time. Since reading involves relatively brief fixations on printed letter strings, then such a deficit could plausibly impede the learning of new printed word forms. A fast-decaying trace would make consolidation of representations in the lexical orthographic store difficult. Since RF had good phonological processing ability (an important core skill for the acquisition of grapheme-phoneme correspondences) he would presumably come to rely on sublexical processing for reading and spelling over time. However, it must be acknowledged that it is impossible to tell whether RF may have had a different type of problem (for example, a phonological deficit) at a younger age. Interpretation must remain speculative at this point, and in addition, as acknowledged above, RF was not assessed for other possible deficits that might explain his literacy difficulties.

It will also be important to investigate in more detail the reasons for the improvement in reading following intervention. An increase in single word reading speed and accuracy was found following intervention in RF's case, and fast single word reading was hitherto equated with lexical processing. However, one cannot be sure whether the improvement was a result of change from sublexical to lexical processing, since an increase in word reading speed and accuracy could have arisen from improvement in efficiency of sublexical processes (for example, due to improved storage of letters for conversion to sound, or use of larger units for print-to-sound conversion). Further testing using experimental techniques such as priming and visual search (see, for example, Ktori & Pitchford, 2009) or examination of the effect of word length on reading (see, for example, Weekes, 1997), would be informative in addressing the issue of whether intervention results in a switch from sublexical to lexical processing.

According to an accumulation of research it seems that in order to carry out effective intervention for literacy difficulties in monolingual and bilingual children, detailed theoretically-based assessment is crucial. The results also reaffirm the important role of intervention studies in testing hypothetical associations of cognitive processes. Most importantly is the implementation of early intervention in order to reduce the number of children falling behind in spelling and writing and to provide more consideration in teaching of spelling as a valuable aspect of literacy acquisition.

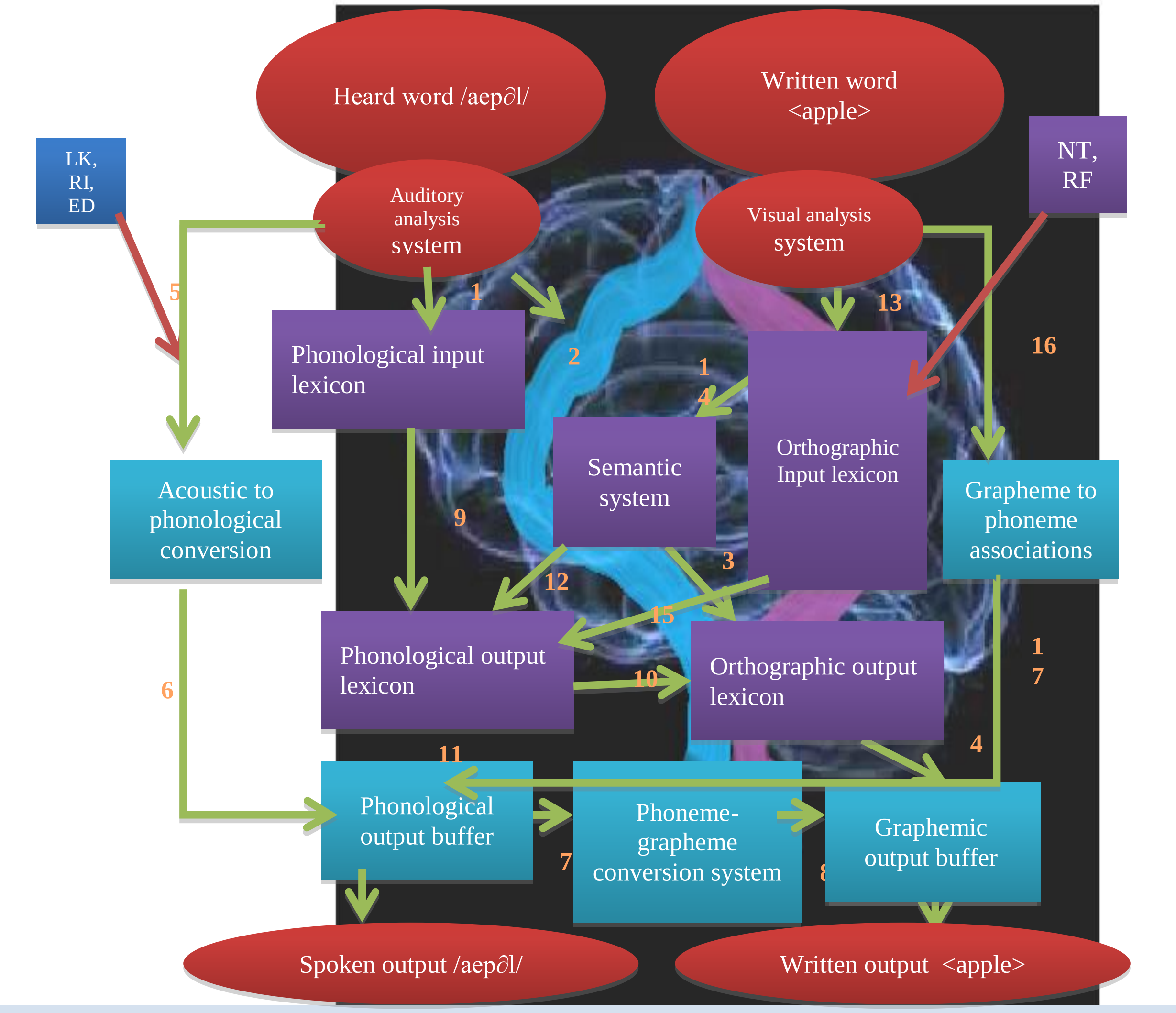


Figure 17: *DR model of reading and writing (adapted from Ellis & Young, 1988, pp. 222)*

As such, the results provide further confirmation that the DR model of spelling can be a useful theoretical framework for specifying the locus of the difficulty in children with spelling deficits and for implementing training (e.g., Brunsdon et al., 2005) unlike research suggesting the opposite (Bishop, 1997). If the assessments indicate a phonological deficit this may suggest that a training targeting the sublexical route will be effective, as was found to be for LK. Instead ED showed improvement in lexical skills and, to a certain extent, sublexical skills following training that targeted whole words. ED may have shown improvement with the sublexical intervention if the programme had been longer in duration. For example, Brunsdon et al.'s (2002, see also Chapter 7) sublexical intervention lasted four and a half months, whereas the present interventions lasted nine weeks. For NT and RF intervention targeting the lexical route was effective. Further research is needed to specify under which circumstances different types of training will be successful. Kohnen et al. (2010) suggest that careful comparison across single case training studies will be necessary to accumulate this information. Figure 17 depicts the locus of the difficutly and the target of intervention for the cases.

LK exhibited poor word and nonword spelling performance indicating difficulties with both routes. Particularly PGCs were underdeveloped for what was expected for his age. His visual memory for designs and sequential memory were impaired. Both LK and RI manifested a difficulty in phonological processing as indicated by their poor performance in spoonerisms. RI also exhibited a difficulty in visual sequential memory, and ED had also a RAN deficit. For these children a sublexical intervention targeting phoneme to grapheme associations (indicated by arrows 5, 6, 7 and 8 in Figure 17) was designed. The intervention was successful for LK as for both languages nonword spelling significantly improved. Irregular word spelling in English did not improve indicating that word specific training is needed in order to achieve correct irregular word spelling (Kohnen et al., 2010, see also Chapter 7). By contrast the same success was not observed after the cessation of the training programme for RI and ED. Therefore for ED a second training targeting the lexical route (indicated by arrows 13, 14, 15, 10, 4 in Figure 17) was conducted. This was successful as both trained and untrained words significantly improved. However, it did not improve nonword reading and spelling.

NT's difficulty was in both lexical and sublexical processing as her spelling of both words and nonwords was impaired. She also exhibited weak receptive vocabulary in both languages in which she was literate. Assessments revealed that she did not have a phonological, RAN or visual memory deficit. NT's main difficulty was manifested in letter report. As simultaneous multi-character processing is considered to be a marker of lexical processing (Ans et al., 1998) an intervention targeting the lexical route (indicated by arrows 13, 14, 15, 10, 4 in Figure 17) was designed. NT showed improvement at immediate and delayed post intervention assessments and gains were sustained over time. Finally, RF exhibited a deficit in letter report and not in PA, RAN or visual memory. He had the characteristics of surface dyslexia/dysgraphia in Greek as described by Douklias et al (2009). An intervention targeting global letter report was designed aiming to improve lexical reading and spelling (indicated by arrow 13, 15, 11 and 13, 14, 3, 15, 10, 4, in Figure 17). Intervention improved single word reading times and accuracy, but it did not improve reading rate or spelling. This indicates that further research is needed in order to investigate the relation between these components and multi-character processing.

8.1.5. *Educational implications*

The emphasis has been on cognitive factors in spelling difficulties but it is also important to consider the educational implications of the work. According to research findings deriving from the present thesis literacy difficulties are affected by writing systems and individual differences in cognitive and language abilities (Singleton, 2002). Since both Greek and English orthographies are inconsistent for spelling, it seems that, based on data from the group and case studies, focus on activities targeting both sublexical and lexical skills are of prime importance in order to enhance children's spelling performance. Supporting only sublexical skill could lead to a reliance on sublexical skills and this is not optimum for spelling in English or Greek, where selection of the correct grapheme for the phoneme and close attention to the exact sequence of letters is important. This is also in agreement with Share (1995), Perfetti (1992) and Ehri (1992) who claim that orthographic representations should become autonomous (with no need for sublexical or semantic feedback in order to achieve accuracy). Representation of the items should be precise in the orthographic lexicon in order to indicate that an orthographic representation of the word has been amalgamated with its phonological and semantic characteristics (Ehri, 1980). Perfetti (1992) claims that lexical quality cannot be achieved through a single encounter with the word. Partial specification of the word characteristics will lead to spelling errors and children might have the profile of partial cue spellers as described by Frith (1980). Similarly, Romani et al. (1999) suggest that ability to encode the exact sequence of letters in words is important for skilled spelling. For English older learners, in order to achieve spelling accuracy book reading seems to play an important role. Primary school teachers need to be aware of the importance of reading books in order to support the successful development of accurate English spelling.

For bilingual children teaching of spelling by employing flash-cards which include semantic and phonetic clues might be useful. Vocabulary was a significant predictor of English spelling of bilingual children even after controlling for age. Therefore vocabulary awareness must be at the forefront of teaching English to bilingual learners. One should also note that awareness of reliance on lexical or sublexical strategies for spelling could also be significant for accurate spelling, depending on whether the child is exposed to an opaque or transparent orthography. These components which can be an optimum or a detrimental strategy for spelling precision should be acknowledged.

Turning now to findings from single case studies the ability to differentiate among subtypes of dysgraphia (and dyslexia) is vitally important for educationalists and clinicians for the purposes of effective intervention. This can only be achieved by detailed assessment and by the use of a theoretical model that can explicitly explain the cognitive components of spelling, such as the DR model. The significance and success of the lexical and sublexical interventions also derives from the fact that it is based on the "zone of proximal development" (Vygotsky, 1978), as in particular, intervention commences from what the student can achieve and with the structured scaffolding of an interactive adult the child develops new spelling strategies and more sophisticated skills. Prior to the intervention, thorough assessment is employed to measure the developmental cognitive abilities the child possesses and the structured and guided teaching exerts its greatest effect on the child's cognitive capacities.

Additionally, regarding the lexical intervention study it seems that training of six items per week could be an optimal number of words in order to achieve consolidation of the trained spellings in the orthographic lexicon. The total number of trained items, 54 for NT and 60 for ED, are sufficient in order to detect statistically significant changes in the intervention according to Kohnen and Nickels (2010). Brunsdon et al. (2005) trained a total of 74 words and Kohnen et al. (2008b) trained 42 words.

It is also worth noting that multilingual children appeared to do better in learning the spellings of words for which they had semantic knowledge. Therefore intervention may be more effective, as it was for NT in the present thesis, if the meanings of unknown words are taught first. The positive result obtained after the intervention indicates that by triggering NT's pre-existing knowledge the new learning was securely acquired. This supports the importance of considering in multilingual classrooms the prior knowledge that the children bring with them. Cummins (2007) stresses that when first language is related to new academic knowledge in the multilingual classroom then this can become a strategy that will mediate as a stepping stone in L2 achievement. According to Cummins (2000) a multilingual child will easily acquire L2 social communication skills but will struggle and take longer to achieve academic language proficiency. Therefore, Cummins emphasises the importance of vocabulary teaching and relating the unknown concept to pre-existing knowledge or to experiences in L1. This component was included in the intervention with NT. Semantic knowledge helps not only multilingual children in spelling acquisition but also monolingual children (Ouellette, 2010, see section 3.2.). The current group studies also demonstrated the importance of vocabulary and print exposure in acquiring spelling awareness even after controlling for age for monolingual and bilingual Greek and English speaking children. In addition, during the intervention immediate feedback was given which according to Fulk and Stormont-Spurgin (1995) has a positive effect in teaching. Immediate feedback provides the opportunity to distinguish between the misspelling and the correct spelling at the point of learning.

In agreement with Fulk and Stormont-Spurgin (1995), results from the intervention programmes indicate that children with literacy difficulties will not spontaneously acquire spelling skill just from exposure to print or invented spelling. It seems crucial that detailed assessment is conducted in order to find the child's specific difficulty and that intervention tailored to the child's deficit is carried out. This applies not only to monolingual children but also to multilingual children, as case studies conducted showed. The significance of the interventions also derives from the fact that they were short in duration so the children did not spend time away from their classroom. They can also be easily implemented by the classroom teacher or a teaching assistant. The interventions involved individual targeted training, which is recommended as vital for a child with learning difficulties (e.g., Rose Review, 2009) and at the same time it does not contradict the philosophy of support and inclusion in the mainstream classroom (Reid, 2013; Norwich & Lewis, 2007). Teachers of children participating in the interventions noted that after the programme children were more enthusiastic and willing to participate in classroom activities, and frequently suggested strategies (such as the visual imagery technique) used during the intervention to their peers or teacher.

The interventions employed require knowledgeable primary school teachers; therefore it is important for teachers' training to include modules on literacy development and effective ways of teaching reading and spelling in both typical and atypical school populations. Additionally, the university programme should help teachers understand that teaching of spelling is not just a visual task achieved through rote learning but it is a linguistic task which requires explicit instruction targeting children's phonological, orthographic, morphological and semantic development (see also for a relevant discussion Garcia et al., 2010) and aiming at supporting children develop their spelling strategies. Montgomery (2007 p 92) also stressed the importance of suitable teacher training. She noted that suitably trained nursery and reception teachers could intervene at an early stage of reading and spelling development and this will be more cost effective than a later interevention with specialist educators.

In general, the findings support previous research (Stuart & Coltheart, 1988; Stuart, 1999; Share, 1999; Stuart et al., 2000) which stresses the importance of phonics teaching and mastering the alphabetic code at an earlier stage of spelling development which will later support encoding of novel words and enlarging children's sight vocabulary. This should not develop independently from orthographic, morphosyntactic skills, semantic ability, language comprehension and production. In summary, it is also very important that teachers understand that written language is dependent upon spoken language ability and that they need to support the development of both equally in the classroom. It is also significant to see learning oracy and literacy as twin processes. Children's language skills will develop in a balanced way if teaching follows a holistic approach. Spoken language and written language will support the development of the other and this should be intertwined with reading high quality books. Language development will be supported through the rich vocabulary, grammar in the structure of the sentences, stories to develop imagination and to give joy (Riley & Burrell, 2007). Reading will motivate children to read more (*Mathew effect* in literacy, Stanovich, 1986). Finally, just seeing words over and over again will develop visual memory and spelling ability.

8.1.6. *Limitations and future research directions*

One of the most important limitations stemming from the current research has to do with the modest sample size of the groups in group Studies 1, 2 and 3. Sample size was small due to the grouping criteria adopted. Thus, a replication of the study with a larger sample would strengthen the conclusions. Moreover, a replication with different opaque and transparent orthographies, also incorporating measures of neuroimaging, would be informative. In the study presented, bilingual children were, in the main, novice learners of Greek. It will be informative to re-assess the children at a later time and investigate if the same patterns regarding their English spelling are observed. It is also important to note that at the Time 2 assessment conducted as part of Study 2b a large number of students were unavailable for retest, due to the fact that children had dropped out from the afternoon school or else they were unwilling to participate.

The monolingual Greek and English children participating in the group studies, although matched in age, differed in years of schooling. This difference in years of schooling might have affected the outcome. However, closer examination of performance in standardized spelling tests did not show significant differences (p>.05) between the monolingual groups, indicating that they were performing at a similar spelling level. Additionally, the aim of the study was not to make comparisons in performance of the monolingual children but to investigate spelling processes and differences in the cognitive processing of bilingual and monolingual children.

Another limitation relates to not obtaining computer calculated reading times for all studies conducted, apart from case study RF. Reading tasks were not administered using computer presentation at the outset of the research but only later on. Therefore only reading accuracy scores were used. However, reading accuracy quickly approaches ceiling in transparent orthographies and so reading accuracy cannot be reliably included in the correlation and regression analyses.

Turning now to the case studies a range of potential difficulties associated with literacy problems were investigated, including a phonological deficit, a visual memory impairment and lack of exposure to print. However, it needs to be acknowledged that there are still other potential deficits that were not assessed in the present research. Ramus and Ahissar (2012) discuss diverse proposals, such as abnormal temporal sampling and anchoring difficulty as explanations of developmental dyslexia. Other possible explanations put forward have to do with difficulty in the perception of phonemes (Ramus & Szenkovits, 2008; Cornelissen, Hansen, Bradley, & Stein, 1996), and prosody perception (Goswami et al. 2011). Facoetti et al. (2010) reported that dyslexic participants are impaired in attentional engagement/disengagement. Since these alternative potential causes were not investigated one cannot exclude a possible deficit in these processes. Another factor strongly related to later literacy achievement is oral language ability (see relevant discussion in Dockrell et al., 2009). This was only partly investigated through receptive vocabulary in the languages in which the children received formal instruction.

Before concluding, it is important to consider as a limitation the fact that during the case studies reported cumulative assessment in a relatively short period of time employing the same spelling and reading standardised batteries for both languages occurred. This could lead to sensitization to the assessment tools (Shipstead et al., 2010). Inclusion of the control group helped address this. Additionally, it should be noted that if for example RF's performance was affected by cumulative testing -and this holds for the other cases as well- he should have improved in all measures. However, this was not the case for irregular word spelling and reading speed. Therefore, the result does not support that improvement was due to repetitive testing. However, it would also be a good solution to have alternative lists of words provided in standardised batteries. Attempts were made to address these threats to internal validity in the present study by including a comparison group and multiple assessment of spelling and reading ability with different tests, but this could be addressed more stringently in future research. A final point that should be made is that although feedback in performance was provided at the end of each period of assessment, the participant received only scores and not his/her performance in tasks. Thus, children between the different time points of assessment did not have any possibility to practise the reading and spelling tests used in the present study.

8.2. Conclusion

The present research demonstrates that spelling accuracy for both monolingual and bilingual English- and Greek-speaking children is not achieved effortlessly. The findings indicated that stumbling blocks encountered by English speaking children are not significantly different from those the Greek speaking children have to overcome in order to spell proficiently. For both orthographies phonological ability seems to play a significant role for accurate spelling at least for the initial stages of literacy acquisition. However, at later stages of literacy development lexically associated variables, such as visual memory and multi-character processing seem to play a more pronounced role, at least for children included in the current thesis. Overall the present studies aimed to add to the growing field of spelling acquisition of monolingual and bilingual children, however there are still more questions that need exploration. It is hoped that the studies may provide a catalyst for further research, so that our teaching of spelling and intervention for those with spelling difficulties will be even more effective.

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Appendices

List of Appendices

Appendix A

A.1. Language experience questionnaire English and Greek

Name of child: ____

Age of child: ____

Place of birth: ____

Tick the appropriate box:

Which is the language spoken at home?

English ☐ Greek ☐ Other ☐

Which language do you speak when you play?

English ☐ Greek ☐ Other ☐

Which language do you think you are better at?

English ☐ Greek ☐

Did you learn to read in English before learning to read in Greek?

YES ☐ NO ☐

Do you speak Greek with your

Parents ☐ Grandparents ☐ Siblings ☐

Do you speak English with your

Parents ☐ Grandparents ☐ Siblings ☐

Are there any other languages that you speak at home? If yes, please write which:

____

Όνομα: ____

Ηλικία: ____

Πού γεννήθηκες; ____

Σημείωσε με Χ το σωστό κουτί:

Ποια γλώσσα μιλάτε στο σπίτι;

Αγγλικά ☐ Ελληνικά ☐ Άλλη ☐

Σε ποια γλώσσα μιλάς όταν παίζεις;

Αγγλικά ☐ Ελληνικά ☐ Άλλη ☐

Σε ποια γλώσσα νομίζεις ότι είσαι καλύτερος;

Αγγλικά ☐ Ελληνικά ☐

Έμαθες πρώτα να διαβάζεις στα Αγγλικά και μετά στα Ελληνικά;

ΝΑΙ ☐ ΟΧΙ ☐

Μιλάς Ελληνικά με

τους γονείς ☐ τη γιαγιά και τον παππού ☐ τα αδέρφια ☐

Μιλάς Αγγλικά με

τους γονείς ☐ τη γιαγιά και τον παππού ☐ τα αδέρφια ☐

Ποια άλλη γλώσσα εκτός από τα ελληνικά και τα αγγλικά μιλάς στο σπίτι;

____

Appendix A.2.

A.2. List of 60 words (Masterson et al., 2008) translated into Greek

τέρας /teras/ (beast)	κήπος /kipos/ (garden)
φταίξιμο /fteximo/ (blame)	ιδιοφυΐα /ithiofiia/ (genius)
καρναβάλι /carnavali/ (carnival)	φάντασμα /fantasma/ (ghost)
χρώμα /hroma/ (colour)	χέρι /heri/ (hand)
κομήτης /komitis/ (comet)	νοσοκομείο /nosokomio/ (hospital)
συμβούλιο /simvoolio/ (council)	τυφώνας /tifonas/ (hurricane)
γρύλος /yrilos/ (cricket)	καγκουρό /kangooro/ (kangaroo)
μέρα /mera/ (day)	λίμνη /limni/ (lake)
ελάφι /elafi/ (deer)	λεμόνι /lemoni/ (lemon)
σκύλος /skilos/ (dog)	φως /fos/ (light)
υπόνομος /iponomos/ (drain)	μαγνήτης /maynitis/ (magnet)
ελέφαντας /elefantas/(elephant)	φίλος /filos/ (friend)
οικογένεια /ikoyenia/ (family)	μοναστήρι /monastiri/ (monastery)
πατέρας /pateras/ (father)	χρήματα /hrimata/ (money)
αλεύρι /alevri/ (flour)	μυστήριο /mistirio/ (mystery)
αποτύπωμα /apotipoma/ (footprint)	ήχος /ixos/(noise)
μύτη /miti/ (nose)	ουρανός /ooranos/(sky)
ενόχληση /enoxlisi/ (nuisance)	σαπούνι /sapooni/ (soap)
ειρήνη /irini/ (peace)	σφουγγάρι /sfoogari/ (sponge)
πίπα /pipa/ (pipe)	καταιγίδα /kateyitha/ (storm)
τόπος /topos/ (place)	ιστορία /istoria/ (story)
πισίνα /pisina/ (pool)	καλοκαίρι /kalokeri/ (summer)

περηφάνια /perifanja/(pride)

πρόβλημα /provlima/ (problem)

ράτσα /ratsa/ (race)

δρόμος /thromos/ (rood)

δωμάτιο /domatio/ (room)

πανί /pani/ (sail)

θάλασσα /thalasa/ (sea)

φώκια /fokja/ (seal)

σιωπή /sjopi/ (silence)

ασημένιος /asimenjos/ (silver)

χελώνα /helona/ (tortoise)

εμπιστοσύνη /empistosini/ (trust)

ατμός /atmos/ (vapor)

σύζυγος /siziyos/ (wife)

λέξη /lexi/ (word)

σκουλήκι /skooliki/ (worn)

Appendix A.3: Greek version of the Spoonerisms task

Item	Item	Correct	Correct
μας /mas/	τον /ton/	τας /tas/	μον /mon/
γάτα /yata/	φίλος /filos/	γίλος /yilos/	φάτα /fata/
μάτι /mati/	τσάντα /tsanta/	τσάτι /tsati/	μάντα /mada/

μες /mes/	φας /fas/	φες /fes/	μας /mas/
λέω /leo/	θες /thes/	θέω /theo/	λες /les/
τον/ton/	που /pooh/	πον /pon/	του /too/
κάτω/kato/	μέσα /mesa/	ματω /mato/	κεσα /kesa/
μπαίνω /beno/	θέλω /thelo/	θαίνω /theno/	μπέλω /belo/
τζάκι /dzaki/	πάνω /pano/	πάκι /paki/	τζάνω /dzano/
τσουλήθρα /tsoolithra/	μπουκάλι /boukali/	μπουλίθρα /boolithra/	τσουκάλι /tsookali/
γκαράζ /garaz/	τζατζίκι /dzadziki/	τζαράζ /dzaraz/	γκατζίκι /gadziki/
καρέκλα /karekla/	μπανάνα /banana/	μπαρέκλα /barekla/	κανανα /kanana/
τσίρκο /tsirko/	ντουλάπι /doulapi/	ντίρκο /dirko/	τσουλάπι /tsoolapi/

A.4.Word analogy task- English

1. anger: angry

   strength: ____________________

2. teacher: taught

   writer: ______________________

3. walk: walked

   shake: ______________________

4. see: saw

   dance: ______________________

5. cried: cry

   drew: _______________________

6. work: worker

   play: ________________________

7. sing: song

   live: ________________________

8. happy: happiness

   high: _______________________

A.5. Λέω την ανάλογη λέξη (Word analogy task- Greek):

1. βάψιμο: βάφω (colouring/ colour)
   γράψιμο: (writing:)__________________
2. διαβάζω: διαβάζει (I read/ he reads)
   θέλω (I want): ____________________
3. τραγουδώ: τραγούδι (I sing/ the song)
   παίζω (I play) : ___________________
4. είμαι: ήμουν (I am/ I was)
   έχω (I have): ____________________
5. πορτοκάλι: πορτοκαλάδα (orange/ orange juice)
   λεμόνι (lemon): __________________
6. κατεβαίνω: κατέβηκα (descend/ descended)
   λέω (say): ____________________
7. αδικία: άδικος (injustice *adverb*/ injustice *adjective*)
   κακία (badness): __________________
8. ακούω: ακούγομαι (I listen/ I am listened)
   κρατώ (I carry): __________________

A.6. List of 50 nonwords used in the 1 minute nonword reading test

ωζέπα	ταναστίκι	τζαλεγκακού	ηκηθοβυλόμου	αδιγαποκιντόπο
αεράπι	μιαγομπός	ητευσκαραπό	σειφτεθράκου	ποτευνοκιάδιμα
ηχναρό	ραρμπούκα	σοροδαρκάμι	χιαντζάρενου	σινεμοιηπόνοκι
αχετρής	εμανιγακά	σολιάνουπης	οτηνικοταύμα	σονεμονυθεύτακο
κονεθάμι	απευρούκας	ωχετράτακας	οντρεδοκεύμα	στρικανολαμπόμα
αδαμόβδι	οταληδόπης	σοροδιμερτά	οτιζεπατρίπος	τσονεμεικιαραφής
ασμιθακό	ηδιβατσάκι	αμοστράτακη	σοτσειταμέχρα	
ιοραύτου	ολόκεμπρης	οναπλορέσας	σονιούνγκιπος	
γιοβλίβας	ονούβραλος	πευσκέκαυνο	στραπαλούντος	
αδιράτσακου	ηκαυτζαμπό	σονεσμιθάκης	σονευσμίχυτης	
οιματζόμα	σοτεαρταχής	σηραχομελοπό	τονεκηθαμολάκι	

Appendix B

Regression analyses with spelling accuracy as the dependent variable and predictor variables global report arrays correct and RAN in Study 3

English spelling

The dependent variable consisted of English spelling scores in the Masterson et al. list. Predictor variables were scores for RAN plus scores for global report (combined score). The overall regression model was significant for the monolinguals, $F(2,33)=9.9$, $p<.0001$ and for the bilinguals $F(2,27)=7.4$, $p<.01$. A summary of the analyses is provided in Table 74 Monolingual English spelling was predicted by letter report and not RAN. Letter report explained 38% of variance in English spelling of the monolingual group whereas RAN explained 10%. A similar outcome was observed for the bilingual children as only letter report predicted spelling accuracy. RAN explained 16% of variance in spelling and letter report explained 29% of variance.

Greek spelling

The dependent variable consisted of Greek spelling scores for the monolingual Greek speaking children in the Masterson et al. list. Predictor variables were scores for RAN plus scores for global report. The overall regression model was significant, $F(2,20)=7.2$, $p<.01$. A summary of the analyses is provided in Table 74. Interestingly, letter report was a significant predictor but not RAN. RAN explained 30% of variance in spelling for the monolinguals and global report explained 32% of variance.

Table 74: *Simultaneous multiple regression analyses with spelling scores (English first and then Greek) as the dependent variables (significant predictions are in bold)*

	Monolingual				Bilingual			
	English Spelling scores							
	B[a]	SE[b]	β[c]	R^2	B	SE	β	R^2
Global report	1.1	.28	**.55*** **	42	1.1	.37	**.50** **	39
Rapid automatized naming	-.17	.12	-.20		-.26	.21	-.21	
	Greek Spelling scores							
Global report	.45	.21	**.42***	55	-	-	-	-
Rapid automatized naming	-.20	.10	-.37		-	-	-	-

Note: [a]Unstandarrdized beta values [b]Standard error of the unstandardized coefficients [c]Standardized beta values, R^2=the proportion of data explained by the model, *p<.05, **p<.01, ***p<.001

Consequently, for all three groups global report was a significant predictor, whereas RAN was not.

Appendix C

NT’s spelling errors with irregular and nonwords for English and Greek prior to the intervention

Irregular word	NT’s response	Nonword	NT’s response
his	✓	un	✓
come	**came**	wup	✓
ball	✓	wem	✓
some	**same**	mon	✓
who	**you**	keet	✓
there	✓	mave	✓
monkey	✓	thent	✓
half	**harf**	sade	✓
ghost	✓	dragell	**dnagel**
know	**now**	pertle	✓
many	✓	sus	**shash**
sugar	✓	gouse	**gash**
want	**wont**	netrich	**netwith**
giant	✓	piclin	✓
island	**irland**	gobner	✓
station	**stasion**	cortue	**corter**
soup	✓	turmness	**tarmnes**
cousin	**casen**	chimpister	**chimpista**
machine	✓	stroise	-
stomach	**stomack**	marzentrate	-
vehicle	**vierkl**	statnic	-

restaurant	**restarant**	banifice	-
parachute	**parasut**	sacranzee	-
reservoir	**resiavuar**	anecoil	-
mosquito	**moskito**	audimental	-
sovereign	-	concipan	-
treacherous	-	wilderdote	-
horizon	-	ostant	-
speciality	-	elephaps	-
miscellaneous	-	experorium	-

Irregular word	NT’s response	Nonword	NT’s response
πλημμυρίζω (flood)/plimirizo/	**πλιμηριζο /plimirizo/**	σότα	✓
εκκλησία (church) /eklisia/	**εκλυσηα /eklisia/**	άρος	✓
τυρί (cheese) /tiri/	**τιρι /tiri/**	τιμαλόνι	✓
μαγειρεύω (cook)/mayirevo/	**μαγηρεγω /mayireyo/**	κράντας/krantas/	**κρανδας/kranthas/**
άγγελος (angel)/agelos/	**αγελος/ayelos/**	τραβαλιάζω	✓
παίζω (play)	**πεζο/pezo/**	ράτσο/ratso/	**ραστο/rasto/**
φωτογραφίζω (i take a photo) /fotoyrafizo/	**φοτογραφιζο /fotoyrafizo/**	λάντο/lanto/	**λανδο/lantho/**
ήχος (sound)	✓	φιλάτροπος	✓
παιδιά (children)	✓	καλαντίνο	✓
ενοχλητικός (nuisance)/enohlitikos/	**ενοχλιτηκος/enoxlitikos/**	λίμπο	✓
γραμματόσημα (stamps)/yramatosima/	**γραματοσιμα/yramatosima/**	σιταρομένος	✓
άρωμα (perfume)/aroma/	**αρομα/aroma/**	ανταρομένη	✓
άγκυρα (anchor)/agira/	**ακγιρα/akyira/**	πανοδία	✓
καθήκον (duty)/kathikon/	**καθικον/kathikon/**	περιοδικλές/periothikles/	**περιδιοκλες/perithiokles/**
ηφαίστειο (volcano)/ifestio/	**ηφεστηο/ifestio/**	λίνταρο	✓
δύσπνοια (difficulty to breath)/dispnia/	**δησπνια/dispnia/**	αποτραδίζω	✓
αστείο (joke)/astio/	**αστιο/astio/**	κέμπες	✓
ζητιανεύω (i beg)/zitjanevo/	**ζιτηανεβο/zitjianevo/**	μπουκαπορτώνω/bookaportono/	**πουκαπορτονο/pookaportono/**
είσοδος (entrance)/isothos/	**ησοδος/isothos/**	άμπολα	✓
μεταβλητός (changeable)/metavlitos/	**μεταβλιτος/metavlitos/**	γάλασσα	✓
		παλαμάρο/palamaro/	**παραμαλο/paramalo/**

σίτιο	✓
ρινιματιά/rinimatia/	**ριμιματια/rimimatia/**
τάμπος	✓
ποτραλάμι	✓
τσάπος/tsapos/	**σταπος/stapos/**
αντιβάζω	✓
ντισκοδία/ntiskothia/	**δισκοδια/thiskothia/**
κέμπες	✓
τιμπαλόνι/timpaloni/	**τιμαλονι/timaloni/**
λιτασομένα	✓
ητορία	✓
σαποκαρόζι/sapokarozi/	**σαροκαραζε/sarokaraze/**
ποράκι	✓
κοντραλιά/kontralia/	**κοτραλια/kotralia/**
νταμάζι	✓
κονφελάριο/konfelario/	**κονφεραλιον/konferalion/**
πάντεμο	✓
τραμπαπολίνο	✓
σεπενέντιο	✓