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Development of Biliteracy in Bilingual Children: Effects on Language and Cognition

PhD in Psycholinguistics

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Abstract

The present thesis provides a comprehensive assessment of Greek-English bilingual children's language and literacy skills in both languages as well as their cognitive abilities. Moreover, patterns of predictors of word reading and reading comprehension are compared between monolinguals and bilinguals, and across the two languages. Different indices of biliteracy were calculated to assess their predictive validity with regard to oral language and executive function skills. Results showed clear bilingual profile effects which were more pronounced in the minority language Greek. Vocabulary was found to be the greatest challenge for bilinguals, and the results showed that vocabulary affected performance on most other oral language and literacy measures. Notably, the bilingual children performed on a par with the monolinguals in measures of basic literacy skills in the majority language English, and only showed a small gap in reading comprehension. The analyses further showed that the pattern of predictors of reading performance was highly similar across groups and languages. However, differences emerged in the relative contributions of the underlying skills in that verbal WM was a better predictor of word reading in the bilinguals, while RAN was a better predictor in the two monolingual groups. Thus, the findings point to the possibility that the bilingual children are able to compensate for their lower vocabulary skills by relying more on their verbal working memory to perform at monolingual levels on basic literacy measures in the majority language. In addition, there was evidence that biliteracy is associated with better performance on tasks tapping working memory and updating, while there was no indication of positive effects of biliteracy on oral language skills in either language. Taken together, the results underscore the pivotal role of vocabulary for performance on oral language and literacy measures, and point to the benefits of developing literacy in the minority language.

Declaration of original authorship

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

Evelyn Egger

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Abbreviations

BIR = Biliteracy Index Reading

BIS = Biliteracy Index Schooling

BL = bilinguals

CPM = Coloured Progressive Matrices (test of non-verbal intelligence)

CQ = comprehension questions

CUP = Common underlying language proficiency

DB = digit backwards

EF = Executive functions

ELL = English language learners

ENG = English

ENNI = Edmonton Narrative Norms Instrument

GLT = Global-Local task

GR = Greek

HLI = Home Literacy Index

LDT = Lexical decision task

LF = Letter fluency

L1-English = English monolinguals

L1-Greek = Greek monolinguals

ML = monolinguals

NVIQ = non-verbal IQ

RAN = Rapid Automatized Naming

RC = reading comprehension

RT = reaction time

SES = Socioeconomic status

SRT = Sentence repetition task

SVR = Simple View of Reading

WM = working memory

CHAPTER 1 – INTRODUCTION

1.1 Background

Given the ever-growing globalization and immigration, bilingualism remains one of the key areas of psycholinguistic research in the 21st century. Consequently, a large body of research has looked at the effects of growing up bilingually on children's linguistic and cognitive development (e.g., Barac & Bialystok, 2012; Bialystok, 2001). While early studies on dual language development have mainly focused on potentially vulnerable areas, such as language outcomes and intelligence (e.g., Darcy, 1953; Jensen, 1962), later studies have also investigated the possible benefits of bilingualism (e.g., Bialystok, 2011). For example, Bialystok and her lab have produced and inspired a series of studies that point to a bilingual advantage in non-verbal cognitive processing starting from early childhood (e.g., Kovács & Mehler, 2009; Sebastián-Gallés, Albareda-Castellot, Weikum & Werker, 2012) and extending into old age (Bialystok, Craik & Freedman, 2007; Craik, Bialystok & Freedman, 2010). However, the findings from this strand of research have recently been criticized on several grounds (Paap & Greenberg, 2013; Paap, Johnson & Sawi, 2015) and there are still factors interacting with bilingualism that remain underexplored. Because bilingualism is such a far-reaching experience that tends to transcend nearly all aspects of everyday life, levels of proficiency in the two languages are affected by a multitude of factors. One of the factors that has consistently been under investigation is educational setting. Given that children spend a considerable amount of their childhood in school, the language of instruction has important consequences for the children's linguistic input and ultimately their levels of proficiency. In fact, effects of educational setting can be quite extensive leading to a switch in the children's dominant language and sometimes even language attrition in the minority language. Imagine a scenario of a child who has been born in Greece to two Greek-speaking parents moving to the UK shortly after. The parents only speak Greek at home and the child is only minimally exposed to English until s/he enters school. Hence upon school entry, the child's dominant language is Greek with English being the weaker language of the two. However, over the years the child's use of English will increase which eventually results in a shift where English becomes the language the child feels more comfortable with, and Greek becomes the weaker language. The decrease in the everyday use of Greek is often accompanied by language attrition, i.e., there is a decrease in proficiency in Greek. Note that this state may only be temporary so that after a certain amount of time spent in Greece, the dominance may shift back and Greek becomes again the stronger language.

In order to prevent such extreme changes in language dominance and more importantly language attrition, maintaining language support in the minority language during childhood is paramount. This is increasingly been recognized and some schools have started to incorporate native language support into the curriculum. However, native language support at regular primary schools is not always feasible due to the large number of different languages spoken by the dual language children. A partial solution to this is provided by Saturday schools (also called Heritage Language schools) where children receive a few hours of additional instruction in the minority language. Saturday language schools not only offer the children additional language input, but they also enable the child to acquire literacy skills in the minority language. This in turn has important ramifications on proficiency levels and the maintenance of native language skills. The reason for this is that literacy provides an additional level of representation of the language in the brain because in addition to the phonological representation of words, they also come to be represented in their orthographic form. According to the lexical quality hypothesis (Perfetti & Hart, 2002), this leads to more stable and higher quality representations of lexical entries that are more resistant to 'forgetting' than entries for which there is only a phonological representation. As such, literacy can be seen as a remedy for language attrition.

From an educational viewpoint, the performance of children whose first language is not the language of instruction has attracted particular attention. This is because numerous investigations, such as the PISA studies, have pointed to lower educational outcomes of children and adolescents who grow up bilingually (OECD, 2010; Stanat & Christensen, 2006). Literacy and reading comprehension in particular, have been shown to be most vulnerable in these learners with many failing to achieve monolingual levels even after many years of schooling in the majority language. Unfortunately, these reports generalize over the whole population of dual language learners, thereby, failing to take into account crucial differences in terms of social background, and native language use and support among this group of children. More specifically, these studies do not distinguish between different types of language learners and typically lack information on the bilingual children's proficiency levels in the other (i.e., minority) language. Focusing on the educational context in England, there is a substantial number of dual language learners in primary school classrooms which was estimated to be nearly 20% in 2015 (DfE, 2015). As a result, there is a growing body of research looking at literacy development of bilingual children. Although the main concern for the majority of these studies is to identify differences and similarities between monolingual and bilingual literacy development, more recent studies have come to look at the possibility of cross-linguistic transfer of underlying skills. Cummins (1978; 1991) proposed the notion of a common underlying language proficiency (CUP) which subsumes a range of skills that underlie language and literacy development. Crucially, the skills that are part of CUP are not specific to a given language which means that knowledge and skills that are acquired in one language can be transferred for application in another language. The primary examples from the literature are skills, such as phonological and morphological awareness (e.g., Pasquarella, Chen, Lam, Luo & Ramirez, 2011; Verhoeven, 2007). Thus, bilingualism confers an advantage in that speakers can transfer certain skills from one language to the other language without having to learn them from scratch. For example, children who have acquired literacy in one language can use some of the underlying skills (e.g., phonological awareness) for the development of reading skills in another language. Numerous studies have provided evidence for the contribution of various L1 skills to L2 literacy (Durgunoğlu, 2002; Proctor, August, Carlo & Snow, 2006; Verhoeven, 1994). Despite the many studies that have investigated literacy development in bilingual children, only few have tried to provide a complete picture of the children's abilities in the two languages. In most studies, the focus is on outcomes in one language only (typically the majority language), while language skills in the 'other language' are not assessed in great detail. Consequently, there is a dearth of research on biliteracy in bilinguals that aim at a comprehensive assessment of language and literacy skills in both languages. This thesis is a small step towards filling this gap by providing a detailed description of the bilingual children's linguistic and cognitive profiles, as well as their literacy skills in both of their languages, English and Greek. The literacy measures obtained in the two languages made it possible to calculate a biliteracy index which could then be used to predict oral language and cognitive skills. Moreover, the wide range of measures obtained within this study offers the opportunity to investigate the relationships between the various skills within each language of the bilinguals. Finally, the results of the present study have implications for fostering literacy skills in the minority language of bilinguals.

1.2 Thesis objectives & overview

The thesis consists of one large study that included three groups of school-aged children, namely Greek-English bilinguals, English monolinguals and Greek monolinguals. The primary focus is on bilingual children, while the monolingual children merely serve as a reference point to put the bilingual children's performances into a broader context. The first aim of the thesis is to provide a comprehensive overview of the bilingual children's language and literacy skills in their two languages, as well as their cognitive abilities. The focus is on children from Year 3-6 at primary school, as this has been shown to be an important stage in their literacy development. The study did not include children from lower grades (Year 1-2) because it was reasoned that their literacy skills in the minority language Greek would be too low, thus preventing them from completing some of the more difficult tasks. The various language and literacy measures were selected and designed to be as similar as possible across languages in order to provide maximum comparability. Identifying bilingual children's strengths and weaknesses is important as it points to ways in which educators and parents can support the children's language and literacy development in the two languages, which in turn, will also have ramifications for their academic achievement. Moreover, comparing and correlating the bilingual children's performances across the two languages indicates which areas or skills might be prone to crosslinguistic transfer.

The second objective of the study is to examine the predictors of word reading and reading comprehension in Greek and English. Many studies have looked at the relationships between oral skills, cognitive abilities and reading development in monolingual and bilingual children. Although these studies have been highly informative for theories of reading acquisition, there are still many conflicting findings and inconsistencies across studies that warrant further investigation. With regard to literacy development in bilingual children, most research has focused on reading outcomes in one language only, typically the majority language. The present study examines the predictors of reading skills across two languages and in two different groups of learners at the same time. Thus, the effects of orthographic transparency and language status (monolingual vs. bilingual) on predictors of reading can be investigated simultaneously. Moreover, the study sought to validate existent theories of reading processes as well as to explore the possible influence of less well-studied skills. The results are useful to educators and language therapists, as they indicate which underlying skills should receive more focus in intervention programs designed for struggling readers, but also in the classroom more generally.

The third aim was to look at the relationship between oral language skills and levels of biliteracy. The importance of oral language skills in literacy development is well established, however, little attention has been paid to the possible contribution of literacy to oral language skills. Although most researchers agree that the relationship is likely to be reciprocal, only few studies have sought to provide evidence for the bi-directional influence of the two skill sets underlying oral language and literacy. Literacy and more specifically reading comprehension, is often described as a ‘higher-order’ skill meaning that it involves complex interactions among numerous sub-skills. Because reading is such an intricate process, it is likely that some of the underlying skills are relatively language independent, and thus, transferable across the two languages in bilinguals. Moreover, these underlying skills might be relevant for performance on tasks measuring oral language, too. In the current study, this idea is explored by looking at the predictive value of different indices of biliteracy for a number of measures of oral language skills in the two languages.

Finally, the fourth objective of the thesis is to shed further light on the debate about possible cognitive advantages conferred by bilingualism. A long line of research has provided evidence for the cognitive benefits of bilingualism but, this body of research has recently been called into question and several researchers have pointed out the inconsistencies and shortcomings of this work. One of the main flaws of many of these studies is that bilingualism is treated as a binary variable and that the criteria for being classified as bilingual vary from study to study. Even when bilingualism is treated as a continuum, there are aspects of the bilingual experience which have not been taken into consideration as yet when exploring cognitive benefits of bilingualism. One of the aspects of bilingualism that has been neglected so far is literacy and more specifically levels of biliteracy. In a nutshell, if bilingualism confers cognitive advantages and these advantages emerge only at higher levels of bilingualism (i.e., higher levels of proficiency in both languages), then bilinguals who are also reasonably biliterate are hypothesized to show even greater benefits. The present study is the first to explore this idea by using different biliteracy indices to predict performance on executive function tasks.

The remaining part of chapter 1 provides the literature reviews regarding the key topics of the present thesis, including the main factors that influence bilingual language development, the linguistic and cognitive profiles of bilinguals, as well as literacy development in monolingual and bilingual children. Chapter 2 presents the methodology starting with a general overview of the three groups of participants which is followed by a detailed description of the bilingual children's profiles drawn on the basis of information obtained via parental questionnaires. Moreover, chapter 2 introduces the experimental tasks and the various measures derived from them, as well as the different biliteracy indices that were calculated for the purpose of this study. The chapter ends with a brief description of the general procedure. The next four chapters contain the results of the study divided according to the main research questions. Chapter 3 is concerned with comparisons between the bilingual children and their monolingual peers in each language. Moreover, the bilingual children's performance on the various measures is compared across the two languages. Thus, chapter 3 gives an overview of the bilingual children's strengths and weaknesses in each of the two languages. Chapter 4 examines the predictors of reading skills (word decoding and reading comprehension) and compares the pattern of predictors across groups and languages. Chapter 5 explores the contribution biliteracy to bilingual children's oral language skills in Greek and English and chapter 6 examines possible effects of biliteracy on executive function skills. Finally, the results from chapters 3-6 are synthesized in the general discussion in chapter 7, followed by the conclusions.

1.3 The bilingual population

1.3.1 Who is bilingual?

Before delving into the large body of research on bilingualism, it is important to determine who is referred to as bilingual. Several terms have been used in the literature including: bilinguals (simultaneous, early successive, late successive), emergent bilinguals, dual language learners, second language learners (L2 learners) and heritage speakers. The use of different terms to refer to speakers of two languages reflects the vast heterogeneity that exists within the bilingual population. In the past, bilingualism used to be quite narrowly defined as native-like proficiency in two languages. However, over the years, researchers came to realize that speakers with equally native-like command of two languages across domains are virtually non-existent (Grosjean, 1982). More recently, a wider definition of bilingualism has been adopted that encompasses speakers of various levels of competence in their two languages which might also differ across domains (e.g., conversational vs. academic language skills; oral language vs. literacy skills). Consequently, the term ‘dominant’ is commonly used to refer to the language in which a bilingual speaker exhibits higher levels of proficiency, while the terms ‘non-dominant’ or ‘weak’ are used to refer to the language that is associated with lower levels of proficiency. Note that these terms are used in a relativistic sense with reference to the other language, so that a speaker can have a ‘dominant’ and a ‘non-dominant’ language, despite having overall very high or very low levels of proficiency in both languages. Because proficiency tends to be a rather subjective measure that heavily depends on the communicative context and the way it is assessed, frequency in terms of how often a bilingual speaker uses his two languages on a daily-basis is often taken as supporting information to determine levels of bilingualism.

Although bilinguals are sometimes still categorized into subtypes – mainly for descriptive and theoretical purposes – the view that bilingualism is best conceptualized as a continuum of language proficiency and use has become increasingly popular. This is also the approach adopted in the present study. Thus, the current bilingual sample included children of Greek descent born in the UK (typically referred to as heritage speakers), children with one English-speaking parent and one Greek-speaking parent (simultaneous bilinguals), children of Greek-speaking parents who moved to the UK during the first years of their life (early successive bilinguals) as well as children from Greek-speaking parents who moved to the UK sometime during (later) childhood (child L2 learners or late successive bilinguals). Hence, what these children have in common is that they are exposed to two languages (English and Greek) on a daily basis (albeit to varying degrees) and that they receive naturalistic input in both languages which distinguishes them from typical foreign language learners[1].

1.3.2 Internal and external factors in bilingual language development

Bilingualism is characterized by high levels of heterogeneity and many factors have been proposed to account for these individual differences. A frequent distinction is made between internal and external factors. Internal factors refer to things that are inherent to the learner such as cognitive maturity, language aptitude (e.g., working memory skills, analytic reasoning), previous language learning experience (i.e., knowledge of an L1), motivation and the like.

[1] Foreign language learners acquire language skills in a second language other than their mother tongue through explicit instruction typically later in life (late childhood or adulthood). Note however, that someone who starts as a foreign language learner may potentially become a bilingual speaker later on in life provided he/she has received additional naturalistic language input in that language and uses both languages on a daily basis.

External factors, on the other hand, are things that are imposed by the learner's environment, in the broader sense, and which determine the quantity and quality of language input that he/she receives in each language (Paradis, 2011). The influence of these factors on bilingual language development has been well documented across different ages and languages. One of the internal factors that has attracted a lot of attention because of its theoretical implications is age of acquisition of the L2, as it determines the cognitive maturity of the learner. The findings from this strand of research suggest that earlier age of acquisition is associated with more native-like outcomes in domains such as phonology and morphosyntax in the long term (e.g. Johnson & Newport, 1989; Meisel, 2009). On the other hand, older learners can benefit from their cognitive maturity which can lead to faster rates of acquisition as reported, for instance, by Golberg, Paradis and Crago (2008) for the domain of vocabulary. Previous language learning experience in terms of existing knowledge of an L1 is another child-internal factor that has been studied extensively, especially in the context of transfer (Chondrogianni & Vasić, 2016). In the relevant literature, it has been argued that certain conditions need to be met in order for cross-linguistic influence or transfer to occur (Hulk & Müller, 2000). For example, the two languages need to present some sort of overlap or structural similarity, although the conflicting findings across studies suggest that similarity between the language systems is not sufficient in explaining the presence or absence of cross-linguistic effects (e.g., Blom, Paradis & Duncan, 2012; Cornips, van der Hoek & Verwer, 2006). Thus, the influence of previous knowledge of an L1 on language development in the L2 is mediated by language-specific properties (among other things), which illustrates the interaction of internal and external factors in bilingual language development.

With regard to other external or environmental factors, amount of input to the two languages has been shown to be a key source of variability in children's language learning experience (e.g., Blom, 2010; De Houwer, 2007; Pearson, Fernandez, Lewedeg & Oller, 1997). Input quantity is difficult to measure as exposure patterns are prone to change across time. Nevertheless, researchers have come a long way in developing questionnaires that provide comprehensive measures of input based on current and previous patterns of exposure to the two languages (Paradis, 2011; Unsworth, 2013). Input effects have been consistently reported for language development in a variety of domains, most notably vocabulary and morphosyntax, especially in terms of rate of acquisition (e.g., Hoff et al., 2012). However, input seems to interact with language dominance as some studies have failed to find input effects in the dominant language of bilinguals (Blom et al., 2012; Golberg et al., 2008). Besides quantity of input, there is a growing number of studies investigating the role of quality of input. For example, Place and Hoff (2011) found that percentage of English input provided by native speakers was positively related with English language skills in 2-year-old Spanish-English bilinguals. Similarly, there is evidence for negative effects of non-native input on bilingual children’s language development that may possibly lead to fossilization (Cornips et al., 2006). Moreover, socioeconomic status (SES) – typically indexed by maternal education levels – has been shown to affect language development in monolingual (Hoff, 2006) and bilingual children alike (Golberg et al., 2008). This is because SES is linked to the quality of the input parents provide to their children so that parents in low SES families tend to exhibit lower levels of education and literacy, and thus, tend to use simpler and less decontextualized language than parents with higher SES (Rowe, 2012). Related to both input quantity and quality is the language of schooling. Overall, research in this area points to the effectiveness of bilingual programs on children’s language and literacy outcomes by supporting the maintenance of the bilingual children’s minority language without compromising language development in the majority language (Baker, Basaraba & Polanco, 2016).

1.3.3 Language profiles of bilinguals

The differential effects of internal and external factors across different language domains are manifested in the language profiles of bilinguals. One domain that has yielded strong and persistent effects of bilingualism is vocabulary. This finding is commonly attributed to the fact that bilingual children receive less input than monolingual children in each language which slows down the rate of lexical development (Oller et al., 2007). Thus, bilingual children generally exhibit lower lexical skills than their monolingual peers in each language (e.g., Bialystok, Luk, Peets & Yang, 2010; Umbel, Pearson, Fernández & Oller, 1992), although if both languages are considered, bilingual children tend to have larger conceptual vocabularies than their monolingual peers (Oller et al., 2007). Quantitative measures of input that have been linked to vocabulary development include home language use (Gathercole & Thomas, 2009; Paradis, Nicoladis, Crago & Genesee, 2011), length of exposure (Unsworth, 2008) as well as literacy-related activities, such as shared book reading and story-telling (Scheele, Leseman & Mayo, 2010). Moreover, studies have shown that expressive vocabulary seems to be more affected by bilingualism than receptive vocabulary and that the receptive-expressive gap tends to be more pronounced in the bilingual children’s weaker language (Gibson, Oller, Jarmulowicz & Ethington, 2012; Gibson, Peña & Bedore, 2014). Regarding the latter finding, some studies have failed to find input effects – as measured by language use in the home – on vocabulary in the majority language of bilinguals (e.g., Chondrogianni & Marinis, 2011; Golberg et al., 2008). This is because input in the majority language is mainly provided through the educational setting, hence the lack of an effect of home language use in the majority language. In line with this, Chondrogianni and Marinis (2011) found that length of exposure – a slightly different measure of input – did have an impact on vocabulary skills in the majority language of the bilinguals. Taken together, the gap in vocabulary between monolingual and bilingual children constitutes a robust finding, although the particular factors that predict lexical development in bilinguals may vary as a function of language status (minority vs. majority language) as well as sample characteristics and the measure used to assess lexical skills.

Studies that have compared morphosyntactic development in monolingual and bilingual children across different languages have produced mixed findings. For example, Pérez-Leroux, Pirvulescu and Roberge (2009) found that French-English bilingual children lagged behind their French monolingual peers in production of direct objects. Similarly, Chondrogianni and Marinis (2011) showed that the bilinguals scored lower than their monolingual peers on a range of grammatical structures and phenomena (3rd person *–s*, past tense, articles, wh-questions, passives), although the particular factors that were associated with bilingual performance differed across the structures tested. In contrast, earlier findings by Paradis and Genesee (1996) suggested no differences between monolingual and bilingual children regarding the acquisition of clausal syntax. It has been argued that the conflicting findings are due to differences in sample characteristics (i.e., exposure patterns) and structural difficulty of the phenomena under investigation (Paradis, 2010). Regarding the latter, findings suggest that complex structures seem to be more affected by the reduced input associated with bilingualism than relatively simple structures (Chondrogianni & Marinis, 2011). For example, Nicoladis, Palmer and Marentette (2007) examined bilingual children's production of regular and irregular past tense forms in English and French. Results showed that bilinguals were less accurate for both regular and irregular past tense forms than their monolingual peers, however, the group differences were more pronounced for irregular forms. Interestingly, the results for French suggested lower performance on part of the bilinguals for irregular verbs only, while accuracy on regular forms did not differ from monolinguals. The difference between French and English with regard to regular past tense forms indicates that the extent to which acquisition of a given grammatical structure or feature is influenced by bilingualism is highly contingent on language-specific properties, i.e., how the given structure or feature is realized. To illustrate, grammatical gender is relatively easy to acquire in languages that provide consistent and abundant morphological cues that can be associated with the different gender categories. Hence, monolingual and bilingual children show comparable rates of acquisition of grammatical gender in languages like Italian (Kupisch, Müller & Cantone, 2002). In contrast, the acquisition of the same grammatical phenomenon in a language with sparse and inconsistent cues to gender is significantly delayed in monolinguals and even more so in bilinguals (Unsworth, 2013). Another factor that seems to affect the size of the difference between monolinguals and bilinguals is amount of exposure. Several studies have provided evidence that amount of input plays a crucial role in morphosyntactic development of bilinguals (Blom et al., 2012; Bohman, Bedore, Peña, Mendez-Perez & Gillam, 2010; Paradis, 2010). Moreover, findings from studies that included measures from both languages of bilinguals suggest that morphosyntactic development in the minority language is more likely to be affected by reduced amount of input than morphosyntactic development in the majority language (e.g., Gathercole & Thomas, 2009; Gutiérrez–Clellen & Kreiter, 2003). In fact, as with vocabulary, some studies have failed to find significant differences between monolinguals and bilinguals in the bilingual children's dominant language (e.g., Paradis, Nicoladis & Crago, 2007; Thordardottir, 2015), supporting the claim that bilingual children eventually reach monolingual levels of proficiency in terms of the acquisition of morphosyntax once they have accumulated a critical mass of input (Gathercole, 2007). Note that in extreme cases, input effects may conspire with age of onset effects, resulting in fossilization, where the acquisition of a particular morphosyntactic or pragmatic phenomenon stagnates before converging on the target grammar (Franceschina, 2005; Montrul, 2006). However, in most cases bilingualism has been found to influence the rate of acquisition rather than ultimate outcomes[2].

Bilingual profile effects also apply to narrative abilities, whereby some sub-skills are more influenced by the bilingual experience than others. Oral narratives are typically analysed on two levels: microstructure and macrostructure (Hughes, McGillivray & Schmidek, 1997; Liles, Duffy, Merritt & Purcell, 1995). Microstructure is concerned with the linguistic form and content of narratives at the utterance level (Heilmann, Miller, Nockerts & Dunaway, 2010), and typically includes measures such as mean length of utterance, productive vocabulary, and lexical diversity, among others. Macrostructure (story grammar and episode structure) refers to the more global features of narratives that go beyond the utterance level, and reflects the ability to narrate a story as a connected whole (Heilmann et al., 2010). Macrostructure is also concerned with overall coherence and the use of mental state verbs to describe the characters' intentions and goal-directed behaviour (Gagarina et al., 2012). Previous studies have shown that both microstructure and macrostructure abilities improve with age from preschool to the early school years (Muñoz, Gillam, Peña & Gulley-Faehnle, 2003; Rojas & Iglesias, 2013; Uccelli & Páez, 2007). Paradis and Kirova (2014) tested 21 child second-language learners of English (ELL) at the end of preschool on a narrative task, as well as on grammatical and vocabulary skills. Results for the narrative measures showed that the ELL children approached monolingual levels on story grammar, while their mean length of utterance was well below monolingual norms (>1SD). Similar results were reported by Paradis, Schneider and Duncan (2013) who found that ELL children were more likely to perform within monolingual norms for narrative macrostructure than for grammatical abilities or receptive vocabulary. The discrepancy in bilingual performance between micro- and macrostructure measures is readily explained by the fact that microstructure skills are highly language-specific, and thus, contingent on proficiency levels, while macrostructure skills are largely language-invariant and render themselves to crosslinguistic transfer.

[2] But see Gathercole & Thomas (2009) for evidence that reduced amount of input associated with bilingualism may lead to incomplete acquisition of plural morphology in Welsh.

The unevenness of performance by bilinguals across tasks is further evident in the domain of literacy. For example, in a large-scale study with Spanish-English bilinguals, Oller et al. (2007) found larger bilingualism effects in the domain of vocabulary than in basic literacy skills, where children tended to perform within monolingual norms. This ties in with findings from a meta-analytic review by Melby-Lervåg and Lervåg (2014), in which group differences between monolingual and bilingual children were examined with regard to reading comprehension and its underlying components. The results showed that the gap between groups was largest for linguistic comprehension skills[3], followed by reading comprehension skills, which showed a moderate effect size, and finally decoding skills, which did not differ from monolinguals. Moreover, the group differences in reading comprehension between monolingual and bilingual children were found to decrease with sample age suggesting that bilinguals are able to 'catch up' over time. In contrast, the group differences in linguistic comprehension skills were found to be relatively stable across the age range included in the meta-analysis (3;6 to 15;6 years). Note however, that the difference between monolinguals and bilinguals in terms of linguistic comprehension skills depends to a large degree on the measure used. For example, D'Angiulli, Siegel and Serra (2001) compared Italian-English bilingual children and English monolingual children on an oral cloze task and found no significant differences. Westman, Korkman, Mickos and Byring (2008) also failed to find group differences between Finnish-Swedish bilinguals and Swedish monolinguals on a task assessing comprehension of instructions. In contrast, the bilingual children in Droop and Verhoeven's (2003) study scored considerably lower on oral language skills in Dutch than their monolingual peers. The group differences were observed in receptive vocabulary, expressive vocabulary, morphosyntactic skills, sentence imitation, as well as listening comprehension skills, even when SES was controlled for. Similar results were obtained in a study by Babayiğit (2014), where bilingual children scored significantly lower on receptive vocabulary, morphosyntactic skills (as measured by a sentence imitation task), and listening comprehension compared to their English monolingual peers. Interestingly, the group difference was considerably smaller for listening comprehension than for vocabulary, confirming that vocabulary is a particularly vulnerable domain in bilinguals. The claim that listening comprehension is less affected by bilingualism than vocabulary and morphosyntactic skills is further supported by results from a recent study by Bowyer-Crane, Fricke, Schaefer, Lervåg and Hulme (2017). The authors compared monolingual and bilingual children on a range of measures across the first two years of formal schooling. Results showed no group differences for listening comprehension, while the bilinguals performed significantly lower than the monolinguals on expressive vocabulary and to a lesser degree also morphosyntactic skills. Finally, the monolingual-bilingual gap in terms of oral language skills (including vocabulary) appears to persist throughout primary school years,

[3] Note that the vast majority of the studies included in the meta-analysis used vocabulary as a measure of linguistic comprehension.

as differences have been reported in longitudinal designs for children across different grade levels (Bowyer-Crane et al., 2017; Droop & Verhoeven, 2003; Jean & Geva, 2009; Verhoeven, 2000).

1.3.4 Executive functions & bilingualism

When research on bilingualism was still in its infancy, it was contended that bilingualism has negative effects on general intelligence (see Diaz, 1983, for review). However, the studies on which this claim was based had serious methodological flaws – the results were confounded by SES – and the statement of detrimental effects of bilingualism on intelligence has been refuted over the years (Darcy, 1953). Nowadays, a large body of research has emerged pointing to a bilingual advantage in executive function skills (see Adesope, Lavin, Thompson & Ungerleider, 2010; Bialystok, 2017, for reviews). Executive function is an umbrella term that refers to a set of cognitive processes that are implicated in everyday activities, such as reasoning, planning, problem solving and multi-tasking, all of which underlie goal-directed behaviour. Within the set of executive functions, researchers have identified three core constructs: shifting, updating and inhibition (Miyake et al., 2000). Shifting (also referred to as switching or cognitive flexibility), is the ability to shift efficiently between multiple operations or mental sets and is typically assessed with task-switching paradigms or set-shifting tasks (Monsell, 2003). Updating involves monitoring incoming information in order to revise items in working memory by replacing information that has become irrelevant with new information and is measured with running span tasks (e.g., Morris & Jones, 1990). Inhibition refers to the ability to control one's attention and to selectively focus on something, while suppressing attention to interfering stimuli. In her review on executive functions, Diamond (2013) lists several tasks that are commonly used to tap inhibitory control, including the Stroop task, the Simon task, the Flankers task, antisaccade tasks, delay-of-gratification tasks, go/no-go tasks, and stop-signal tasks. Miyake et al. (2000) found that inhibition, shifting and updating are separable constructs, but also share some underlying commonality which led them to conclude that the EF system is characterized by both unity and diversity[4]. Working memory is another component that has been frequently invoked in the description of the executive function system, although views on how it relates to the other three components differ (see McCabe, Roediger, McDaniel, Balota & Hambrick, 2010). One of the most influential accounts of the working memory system proposed by Baddeley and Hitch (1974) postulates three subcomponents, a central executive and two subsidiary components, one for the storage of verbal information and one for visual information (see also Baddeley, 2000, for an updated version of the model). Working memory is assessed with tasks that require both

[4] Miyake and Friedman (2012) have postulated an updated model of the organization of the executive function system where the inhibition component is entirely taken up by a common EF component while the shifting and updating components continue to exhibit variance that cannot be attributed to the common EF component.

temporary storage and processing of either verbal or visual stimuli, and is distinguished from short-term memory which requires storage only.

The central idea behind the claim that bilingualism leads to cognitive advantages has to do with the joint activation of both languages in the brain which leads to a situation of continuous conflict (Bialystok, 2017). More specifically, it has been shown that the two languages of a bilingual are simultaneously activated at any given time (e.g., Blom, Küntay, Messer, Verhagen & Leseman, 2014; Costa, Caramazza & Sebastian-Galles, 2000; Kroll, Bobb, Misra & Guo, 2008; Kroll, Bobb & Wodniecka, 2006; Thierry & Wu, 2007), which requires the bilingual speaker to constantly inhibit one of the two languages when conversing with monolingual speakers (Green, 1998). Thus, it has been argued that the need to control attention to the target language in the face of the activated and competing non-target language lies at the root of the cognitive advantage of bilinguals (Bialystok, 2008). Crucially, the mechanism that is responsible for language selection in bilinguals is hypothesized to be domain-general, which explains why effects of bilingualism can be observed in non-verbal cognition, i.e., executive function skills (Bialystok, 2017). Turning to experimental evidence for the cognitive advantage of bilinguals, inhibition is the component that has most frequently been associated with superior performance of bilinguals compared to monolinguals (e.g., Bialystok, 1999; Bialystok & Martin, 2004; Bialystok & Viswanathan, 2009; Carlson & Meltzoff, 2008; Poarch & van Hell, 2012). For switching (i.e., shifting), the findings from previous research are more mixed, with some reporting better performance by bilinguals compared to monolinguals (e.g., Prior & MacWhinney, 2010; Wiseheart, Viswanathan & Bialystok, 2016), and others failing to find evidence for a bilingual advantage in task switching (Paap & Greenberg, 2013). One reason for the conflicting findings might be differences in the task designs that were used to assess switching abilities, as pointed out by Hernández, Martin, Barceló and Costa (2013).

According to Bialystok (2008) there is no obvious reason why bilingualism should affect working memory or updating other than as a by-product of the general enhancement of the executive control system. Accordingly, there is less research looking at the effects of bilingualism on these two components. Nevertheless, some studies found bilingual advantages in these aspects of executive function, too. For example, Morales, Calvo and Bialystok (2013) tested 5- to 7-year old children on a series of tasks with different demands on working memory. The results showed a bilingual advantage in visuospatial working memory, particularly in tasks with higher EF demands (see Blom et al., 2014, for similar results). These findings are in line with the view that the EF components – although separable – are connected through a common underlying mechanism, so that enhancement of one component will indirectly lead to enhancements in the other components (Morales et al., 2013). However, in a recent study, Blom, Boerma, Bosma, Cornips and Everaert (2017) failed to find evidence for a bilingual advantage in verbal and visuospatial working memory. Instead, the bilinguals outperformed the monolinguals on a task tapping selective attention which is consistent with the hypothesis that it is not the inhibition component that is primarily affected by bilingualism, but selective attention (Chung-Fat-Yim, Sorge & Bialystok, 2017). Thus, if it was indeed selective attention that is directly affected by bilingualism rather than inhibitory control, it would partly explain the mixed findings for the four components across different studies and tasks.

On the other hand, the results of previous research have been called into question on several grounds, such as inadequate statistics, small sample sizes and publication bias, among others (Paap & Greenberg, 2013; Paap et al., 2015; Valian, 2015). It is also widely recognized that task-impurity is a central problem in the study of executive function skills. Task-impurity refers to the fact that tasks, which are designed to tap into EF processes, inadvertently implicate other non-EF processes (e.g., perceptual processing). This and the rather vague definition (and elusive nature) of executive function skills make it difficult to measure the variables of interest (Miyake & Friedman, 2012). Nevertheless, a substantial body of research has established a set of EF tasks that have been consistently related to one of the several component skills. Finally, differences across studies might also arise due to sampling characteristics and more specifically, due to differences in bilingual proficiencies across samples in studies that employed a group design. Thus, the null finding might be explained by insufficient levels of bilingualism since there is evidence that the positive effects of bilingualism only arise when a certain level of proficiency has been acquired in both languages (Blom et al., 2017). Consequently, the relationship between bilingualism and executive function skills warrants further research to identify specific aspects of the bilingual experience that lead to cognitive advantages.

1.4 Reading development

1.4.1 Word decoding

Numerous studies have investigated the acquisition of decoding skills across different languages (e.g., Caravolas et al., 2012b; Gottardo, Pasquarella, Chen & Ramirez, 2015; Ziegler et al., 2010). These studies have shown that the development of decoding skills in alphabetic languages relies heavily on phonological processing abilities, i.e., phonological awareness, phonological memory, and rapid automatized naming (e.g., Bradely & Bryant, 1983; Wagner, Torgesen & Rashotte, 1994). Phonological awareness is the ability to recognize and manipulate the relevant units in a particular spoken language (syllables, onset-rimes, phonemenes). Research has shown that phonological awareness is among the best predictors of word reading skills in alphabetic languages regardless of differences in orthographic consistency (Melby-Lervåg, Lyster & Hulme, 2012). Rapid automatized naming (RAN) refers to the speed of lexical access in terms of the integration of visual information with stored representations, the retrieval of phonological labels, as well as the process of articulation (Wolf & Bowers, 1999).

Importantly, RAN has been shown to be a reliable predictor of reading performance independently of verbal ability, phonological awareness, and pure processing speed (Bowey, Storey & Ferguson, 2004; Manis, Seidenberg & Doi, 1999). Further evidence for the importance of phonological processing skills for reading acquisition comes from studies showing that poor phonological awareness or naming-speed deficits are the major causes of reading disabilities, such as dyslexia (Swan & Goswami, 1997; Wolf & Bowers, 1999). However, some researchers argue that the relative importance of the various phonological processes for literacy acquisition differs across languages that vary in orthographic transparency. More specifically, phonological awareness and phonological decoding skills (i.e., the ability to accurately read pseudowords) have been found to be among the best predictors of word reading skills in languages with opaque orthographies, such as English, while their contribution in languages with transparent orthographies seems limited (Georgiou, Parrila & Papadopoulos, 2008; Jong & Leij, 1999; Smythe et al., 2008). In contrast, there is evidence that RAN shows stronger associations with word reading skills in transparent orthographies, like German, compared to opaque orthographies like English (Landerl & Wimmer, 2008; Wimmer, 1993). These findings are inconsistent with some recent studies, where the relative contributions of reading subskills were found to be the same across languages that differ in orthographic consistency (e.g., Caravolas et al., 2012b; Furnes & Samuelsson, 2011; Patel, Snowling & de Jong, 2004; Ziegler et al., 2010). Georgiou et al. (2008) argued that the mixed findings are likely due to the specific tasks used to measure phonological skills, as well as reading ability (accuracy vs. fluency). Moreover, there is evidence that the relationship between different apects of phonologocal skills (e.g., phonological awarenss, RAN) and reading changes throughout development. For example, Kirby, Parrila and Pfeiffer (2003) found that phonological awareness made a strong contribution to reading accuracy in English in the first grades of schooling with the link continuously attenuating over the following years. At the same time, their results showed an increase in the contribution of RAN to reading accuracy across elementary grades, which is taken as an indication of a change in reading strategy from phonological recoding to automatic sight-word reading (Vaessen & Blomert, 2010). A number of studies have explored the contribution of (verbal) working memory skills to word decoding. For example, in a study by Gottardo, Stanovich and Siegel (1996), verbal working memory predicted a small amount of unique variance (4.5%), once phonological awareness and syntactic processing skills were accounted for (see also Christopher et al., 2012). Moreover, commonality analyses revealed that nearly all of the variance accounted for by working memory was shared with phonological awareness and syntactic processing. In contrast, phonological awareness uniquely accounted for 15-20% of the variance in word decoding, suggesting that phonological awareness is a stronger predictor of word reading skills than verbal working memory. Thus, while researchers agree that phonological processing abilities play a central role in reading development across languages, the relative importance of the various sub-skills may vary as a function of language-specific properties as well as reading proficiency.

While the role of phonologial processing skills for early literacy is well established, research has identified several other predictors of basic reading skills. For example, functional awareness or knowledge of print concepts and oral language have consistently been linked to reading outcomes across early grades in school (Scarborough, Shapiro, Accardo & Capute, 1998). According to Kirby, Desrochers, Roth and Lai (2008), vocabulary is related to reading ability in at least two ways. At the level of reading comprehension, readers need to be able to access the meaning of the majority of words in order to understand the text. At the level of decoding, vocabulary knowledge speeds up the word recognition process by allowing the reader to access orthographic represenations directly (i.e., holistically) without having to apply the grapheme-to-phoneme correspodence rules to each letter individually. In line with this, several studies have found relationships between expressive vocabulary and word reading performance (Chiappe , Chiappe & Gottardo, 2004; Ouellette, 2006). For example, Nation and Snowling (2004) showed that expressive vocabulary and broader language skills (i.e., listening comprehension and semantic skills) predicted word decoding both concurrently and longitudinally over and above non-verbal ability, phonological awareness, and non-word reading. In contrast, in a study by Muter, Hulme, Snowling and Stevenson (2004), vocabulary did not predict word reading in first grade (see also Schatschneider, Fletcher, Francis, Carlson & Foorman, 2004). Moreover, Ricketts, Nation and Bishop (2007) argued that vocabulary is only related to exception word reading since their data did not show any effects of lexical skills on text reading accuracy or regular word reading in English. Given the mixed findings from previous research, the nature of the relationship between vocabulary and word reading remains unclear. It is possible that the impact of vocabulary on word reading only emerges at later stages and that word reading during initial stages is largely dependent on phonological skills (Ouellette & Beers, 2010). However, this is at odds with findings from more transparent languages, like Dutch, since Verhoeven, van Leeuwe and Vermeer (2011) found that vocabulary made a small contribution to word reading skills in Dutch, but only in the lower grades. Verhoeven et al. (2011) came to the tentative conclusion that vocabulary might be less important for the development of word reading skills in languages with transparent orthographies (Suggate, Reese, Lenhard & Schneider, 2014; Ziegler & Goswami, 2005). Finally, there is evidence that some executive function skills (other than working memory) contribute to word decoding, too (Altemeier, Abbott & Berninger, 2008; Arrington, Kulesz, Francis, Fletcher & Barnes, 2014; Messer, Henry & Nash, 2016).

1.4.2 The Simple View of Reading and beyond

The ability to comprehend written text is the key to academic achievement. It is therefore not surprising that reading comprehension has attracted so much attention among educators and researchers alike. Reading comprehension is central to academic achievement, since much of the learning process in nearly all school-subjects depends on successful comprehension of written text. Unlike oral language skills, literacy is something that needs to be taught explicitly. Being such an intricate and multi-faceted process, understanding the various skills that contribute to reading comprehension is paramount to inform teaching practices. Essentially, reading comprehension requires the ability to decode written text and knowledge of the words' meanings. This basic description of the reading process is captured in the Simple View of Reading (SVR; Gough & Tunmer, 1986; Hoover & Gough, 1990), which is one of the most influential theoretical accounts of reading comprehension to date. The SVR states that reading comprehension is the product of decoding and linguistic comprehension, whereby both of the skills are necessary but neither is sufficient on their own for successful reading comprehension (Joshi & Aaron, 2000b). Consequently, reading comprehension is compromised in readers with a deficit in either decoding skills or linguistic comprehension, or both (Catts, Adlof & Weismer, 2006). In addition, research that sought to validate the SVR has revealed a developmental shift in terms of the relative contributions of these two basic component skills to reading comprehension as a function of text difficulty (e.g., Catts, Hogan & Adlof, 2005; Gough, Hoover & Peterson, 1996). This is readily explained by the fact that the written texts, that children are faced with in the lower primary grades, contain relatively basic language since the purpose of reading instruction during early stages is primarily to improve reading fluency. In contrast, the main goal of reading in the upper grades of primary school is to acquire content knowledge in the different subject areas[5]. At this stage, children have developed adequate word reading skills and individual differences in decoding abilities have levelled out, leaving little variation at the group level. As a result, the contribution of word reading skills to reading comprehension diminishes, while the influence of oral language skills increases because of the large variation in the more advanced language skills required by the written texts children encounter in the higher grades (Tilstra, McMaster, Van den Broek, Kendeou & Rapp, 2009).

The SVR has proven to be a good starting point to study the development and underlying processes of reading comprehension. Nevertheless, it is clear that reading is a highly complex process that involves more than just decoding abilities and listening comprehension skills. As a result, there have been several attempts to modify the SVR by adding other factors in order to improve its ability to predict reading comprehension skills. For example, Joshi and Aaron (2000b) proposed the 'Componential Model' of reading comprehension which extends the SVR by adding processing speed as an additional component. The model was based on their results, which showed that processing speed (as measured by rapid serial naming of letters) accounted for an additional 10% of the total variance in reading comprehension of third-grade

[5] This difference in the purpose of reading is commonly referred to as a transition from 'learning to read' to 'reading to learn'.

children. Thus, the inclusion of naming speed led to a significant improvement in the predictive ability of the original SVR. However, in a subsequent study, Johnston and Kirby (2006) found that naming speed (as measured by a RAN with objects task) only made a small contribution to reading comprehension over and above decoding and listening comprehension in grades 3 to 5. The authors concluded that naming speed contributes to reading comprehension primarily through word reading (i.e., lexical access) and hypothesized that the relatively small effect of naming speed compared to that reported by Joshi and Aaron (2000b) might be due to the fact that letter-naming bares a much closer relationship to reading than object-naming (see Manis, Doi & Bhadha, 2000). Related to processing or naming speed, other researchers have proposed reading fluency (i.e., reading rate) as an additional component of reading comprehension (Kershaw & Schatschneider, 2012; Silverman, Speece, Harring & Ritchey, 2013). For example, Tilstra et al. (2009) showed that reading fluency contributed to reading comprehension in English over and above decoding and listening comprehension skills. Moreover, it has been suggested that in the higher primary grades, reading fluency replaces word reading accuracy as a predictor of reading comprehension (Language & Reading Research, 2015). Other studies have found significant contributions of verbal working memory to reading comprehension even after controlling for general cognitive ability, word decoding, and oral language skills (Cain, Oakhill & Bryant, 2004; Christopher et al., 2012; Wong et al., 2017). In line with this, Nation, Adams, Bower-Crane and Snowling (1999) found that poor comprehenders tend to have deficits in verbal working memory. In addition to working memory, other aspects of executive function, such as planning, sustained attention and attentional control (i.e., inhibition) have also been associated with reading comprehension (Altemeier et al., 2008; Arrington et al., 2014; Conners, 2009; Sesma, Mahone, Levine, Eason & Cutting, 2009). With regard to metalinguistic skills, Casalis and Louis-Alexandre (2000) found evidence for an association between morphological awareness and reading comprehension in a longitudinal study with French primary-school aged children (see Kirby et al., 2011, for similar results). Finally, reading development in both monolinguals and bilinguals has also been associated with a particular aspect of oral language skills, namely narrative abilities (Griffin, Hemphill, Camp & Wolf, 2004; Miller et al., 2006; Speece, Roth, Cooper & De La Paz, 1999). This is often explained by the fact that oral narration and written text share some common properties, and thus, require similar underlying skills (Roth, Speece, Cooper & Paz, 1996). Both involve extended pieces of discourse and are typically characterized by the use of decontextualized language (i.e., they do not relate to the immediate environment). Decontextualized discourse is more sophisticated than contextualized language in that it uses more concise and complex syntax, and contains more specialized and abstract vocabulary (Roth, Speece & Cooper, 2002). Moreover, it has been argued that comprehension and production of oral narratives requires certain higher-level cognitive skills (e.g., recall and integration of relevant information, planning, understanding causal and temporal relationships, inferencing, knowledge of story structure, etc.) which have been shown to promote literacy development (Curenton, Craig & Flanigan, 2008; Reese, Suggate, Long & Schaughency, 2010)

1.4.3 Reading development in monolingual and bilingual children

Regarding the development of decoding skills, Verhoeven (2000) found that word reading in Dutch was predicted by the same underlying processes in monolinguals and bilinguals, namely word blending (an aspect of phonological awareness) and letter knowledge. Geva, Yaghoub-Zadeh and Schuster (2000) report similar results for English, in that the amount of variance accounted for by phonological awareness and rapid naming was highly comparable in monolinguals and bilinguals, suggesting that monolinguals and bilinguals acquire basic literacy skills in a similar manner (see also Chiappe, Siegel & Wade-Woolley, 2002; but see Jongejan, Verhoeven & Siegel, 2007, for different results). With regard to the contribution of vocabulary to word reading in bilinguals, like with monolinguals, studies have yielded mixed findings, with some showing significant associations between the two skills (Bellocchi, Tobia & Bonifacci, 2017; Lindsey, Manis & Bailey, 2003), and others failing to find evidence for such a link (Durgunoğlu, Nagy & Hancin-Bhatt, 1993; Geva et al., 2000). The contribution of verbal working memory to word reading observed in monolinguals has been replicated with bilingual samples too. For example, Geva and Siegel (2000) examined the contribution of memory skills to word decoding in a sample of primary school-aged children attending an English-Hebrew day-school in Canada. Children were assessed on both short-term (word recall) and verbal working memory skills (listening span), as well as on word reading abilities in both languages. Results showed that working memory was a stable predictor of word reading in both languages, accounting for 5-6% of the variance after controlling for age differences. Interestingly, the joint contribution of the memory measures was larger in English (L1) than in Hebrew (L2) which, according to the authors, is because the inconsistency of the English orthography requires the reader to process the written input in larger units than just single letters. Age also explained more variance in English (13%) compared to the minority language Hebrew (5%). Finally, inspection of the developmental patterns across grade levels revealed effects of orthographic consistency, in that the rate of acquisition was faster in the relatively transparent vowelized Hebrew orthography (despite it being the minority language) than in English. Geva and Siegel's findings illustrate that the development of early reading skills in bilinguals proceeds faster in languages with transparent orthographies than in languages with opaque orthographies. This is consistent with crosslinguistic comparisons of reading development in monolingual children which show different trajectories depending on orthographic transparency (Seymour, Aro & Erskine, 2003). Taken together, research suggests that the development of early reading skills in monolinguals and bilinguals relies on the same set of skills, although the relative importance of the underlying components may differ as a function of language-specific properties (Geva & Wang, 2001).

The view that reading comprehension in monolingual children primarily depends on word decoding skills and linguistic comprehension is well established and has been confirmed in numerous studies (e.g., Catts et al., 2006; Chen & Vellutino, 1997; Johnston & Kirby, 2006; Kendeou, Van den Broek, White & Lynch, 2009; Nation & Snowling, 2004). However, as with the development of word reading skills, there is evidence for crosslinguistic differences in the relative contribution of the component skills as a function of orthographic transparency. More specifically, findings suggest that oral language plays a more prominent role compared to decoding skills for early literacy development in transparent languages (e.g., de Jong & van der Leij, 2002), while studies conducted in English typically show that the role of oral skills gradually increases over the years (e.g., Florit & Cain, 2011). The relationship between word decoding, oral language skills and reading comprehension has also been established in bilingual populations (Bonifacci & Tobia, 2017; Hoover & Gough, 1990; Proctor, Carlo, August & Snow, 2005). However, group comparisons generally show that bilinguals tend to perform lower on measures of reading comprehension than their monolingual peers (see Melby-Lervåg & Lervåg, 2014, for review). A handful of studies have directly compared predictors of reading comprehension in monolingual and bilingual children. For example, Babayiğit (2015) compared the strength of the relationships between word reading, oral language skills and reading comprehension in monolingual and bilingual children who were developing literacy in English. Results showed that the contribution of oral skills to reading comprehension was highly comparable across groups, although there was a tendency for a stronger link between the two skills in the bilinguals. Droop and Verhoeven (2003) reported similar results for Dutch, in that the pattern of predictors was the same in monolinguals and bilinguals, but the oral language skills played a more prominent role for reading comprehension in the bilinguals compared to the monolinguals (see also Verhoeven, 2000; Verhoeven & van Leeuwe, 2012). This is line with results from Proctor et al. (2005) who examined the contributions of the component skills to reading comprehension in Spanish-English bilingual children and observed particularly strong associations between English vocabulary knowledge and reading abilities. In their study, vocabulary assumed both proximal and distal relationships (via decoding) with reading comprehension, while listening comprehension made a direct contribution only. Thus, previous research indicates that among oral language skills, vocabulary assumes a particularly crucial role for the reading development of bilinguals.

Recall that oral language skills, and especially vocabulary, are consistently found to be more limited in bilingual children's individual languages than in monolingual children (Bialystok et al., 2010; Melby-Lervåg & Lervåg, 2014). However, both phonological awareness and letter-sound knowledge have been shown to develop very similarly in monolinguals and bilinguals and in certain instances, bilinguals show superior phonological awareness abilities (August & Shanahan, 2006; Bialystok et al., 2005; Bialystok, Majumder & Martin, 2003; Chiappe, Siegel & Gottardo, 2002). Consequently, the bilingual children’s lower performance on measures of reading comprehension has been related to limitations in oral language (Babayiğit, 2015; Burgoyne, Whiteley & Hutchinson, 2011; Cobo-Lewis, Eilers, Pearson & Umbel, 2002a; Lervåg & Aukrust, 2010; Melby-Lervåg & Lervåg, 2014). This is because comprehension of written text is compromised if more than 3% of the words are unknown to the reader (Carver, 1994). Thus, the larger contribution of oral skills to reading comprehension in bilinguals suggests that oral proficiency is at least partly responsible for the attested differences between monolinguals and bilinguals in reading comprehension (Melby-Lervåg & Lervåg, 2014). In their meta-analysis, Melby-Lervåg and Lervåg (2014) further found that a number of variables moderated the group differences between monolinguals and bilinguals in reading comprehension and oral skills. For reading comprehension, the type of test used to measure reading skills reliably explained differences between studies. For oral language skills, group differences tended to be larger for bilingual children from low socioeconomic backgrounds and for children who used exclusively the minority language at home. Type of test used was another reason for the variation across studies with vocabulary consistently yielding larger group effects than other measures of oral language proficiency.

1.4.4 Biliteracy

Despite the considerable body of research examining reading development in dual language learners in both monoliterate and biliterate contexts, only a handful of studies have directly addressed the issue of biliteracy in bilingual children (Reyes, 2012). Biliteracy is the ability to read and write in two languages and is best viewed as a particular aspect of bilingual competency (Hornberger, 2003). However, definitions of bilingualism are mainly concerned with oral skills and only rarely make reference to reading and writing skills in each language. This might partially explain why the relationship between bilingualism and biliteracy has remained relatively underexplored. A small number of studies have directly compared performances of groups of monoliterate and biliterate bilingual children across a range of tasks. For example, Schwartz, Leikin and Share (2005) compared two groups of Russian-Hebrew bilingual children – one monoliterate in Hebrew and one biliterate – and monolingual Hebrew children on a variety of linguistic, metalinguistic and cognitive tasks at the end of the first year of formal schooling. Initial results showed significant advantages of the biliterate bilinguals over the other two groups on fluid intelligence, reading fluency measures in Hebrew and phonological awareness tasks. No group differences emerged for the linguistic tasks in Hebrew which included receptive vocabulary, working memory and rapid serial naming. However, the biliterate bilinguals had started literacy instruction (in Russian) earlier than the other two groups (in Hebrew), so a follow-up study was conducted that included an additional Hebrew monolingual group that had acquired basic literacy skills before entering school (Schwartz, Share, Leikin & Kozminsky, 2007). The comparison between the biliterate bilinguals and the early-literate Hebrew monolinguals showed that the biliterate bilinguals were superior on 8 out of the 9 reading measures, although the difference only reached statistical significance for measures of word and pseudoword reading accuracy. Moreover, the biliterate children performed better than the monoliterate bilinguals on Russian measures of phonological awareness, receptive vocabulary, and syntactic awareness. In a later study, Leikin, Schwartz and Share (2010) further showed that biliteracy is a better predictor of Hebrew literacy than bilingualism per se[6]. Taken together, the findings from this set of studies suggest that acquiring literacy in the minority language is associated with better oral skills in that same language as well as with benefits for the development of literacy in the majority language, at least during initial stages. Whether the advantage of biliterate bilinguals over monoliterate bilinguals extends to later stages of reading development needs to be investigated in future studies. Another strand of research has examined the effectiveness of bilingual instruction during primary school years. Generally, results from these studies show that children who are educated in both languages show better knowledge of the minority language than bilingual children attending mainstream programmes (i.e., programmes were instruction is provided exclusively in the majority language such as English-only programmes), while at the same time they perform at equal levels on language and literacy measures in the majority language (Baker et al., 2016; Baker et al., 2012). Moreover, bilingual education has been associated with advantages in executive function skills. For example, Marinis, Bongartz and Tsimpli (under review) found that bilingual education predicts updating skills, as measured by performance on the 2-back task. Children who received balanced bilingual education (i.e., roughly equal amounts of instruction in both languages) outperformed bilinguals who were educated in predominantly one language. Similarly, Bialystok and Barac (2012) studied metalinguistic and executive function skills in children attending two different immersion programmes in Canada and found that performance on the executive control tasks improved as a function of time spent in the immersion programmes.

Another phenomenon that has received a lot of attention in the literature on bilingualism and biliteracy is transfer. Biliteracy development is an interesting area to study the transferability of skills because of the multitude of processes that underlie reading and writing. A prominent idea within research on transfer is that some language and literacy skills are underpinned by a central processing system or a common underlying proficiency that is shared

[6] Note however, that the authors used multiple-regression analysis with non-verbal IQ as the only control variable and contrast-coding for bilingualism and biliteracy. Thus, the study suffers from similar limitations as many previous studies, since bilingualism and biliteracy were treated as binary variables, thereby eliminating crucial within-group variability.

across languages (Cummins 1979, 1991). Hence, there are certain literacy concepts and strategies that are thought to be universal and can thus be applied across languages, while others are language-specific and do not render themselves to transfer (Durgunoğlu, 2002). Support for the interdependence of skills comes from numerous studies that show significant crosslinguistic associations for literacy-related abilities, such as phonological and morphological awareness (e.g., Durgunoğlu et al., 1993; Wang, Perfetti & Liu, 2005). Moreover, Verhoeven (1994) showed that transfer of literacy skills can proceed in either direction (i.e., from L1 to L2 and from L2 to L1). Notably, findings of crosslinguistic contributions of language and literacy skills in language A to reading performance in language B are often interpreted as evidence for positive effects of bilingualism or biliteracy. However, Proctor and Silverman (2011) pointed out that the interpretation of these crosslinguistic relationships is difficult due to confounds between within-language predictors and the measures used to index bilingualism or biliteracy. The problem was illustrated in their study with a sample of Spanish-English bilingual children from grades 2 to 4 who were attending an English-only primary school, hence, all children were literate in English. Literacy in Spanish was measured by means of a word reading test so that children with very limited performance or non-performance on Spanish word reading were classified as monoliterate, while children who could complete the assessment were classified as biliterate to varying degrees, depending on their scores. When biliteracy was treated as a dichotomous variable, the biliterate children outperformed the monoliterate children on Spanish language and literacy measures, as well as on English literacy measures, but not English language measures. Treating Spanish decoding as a continuous variable yielded similar results, in that Spanish decoding (i.e., biliteracy) was a significant predictor of literacy-related skills in English. A closer look at the correlations between measures revealed that Spanish decoding was highly correlated with English decoding, which in turn showed substantial correlations with the English literacy measures that were used as dependent variables. Thus, when English decoding skills were entered into the analyses, the effects of biliteracy (Spanish decoding) disappeared, suggesting that English decoding was a better predictor of literacy skills in English than Spanish decoding. Proctor and Silverman (2011) noted that while it is indeed possible that literacy in Spanish was responsible for the superior performance of 'biliterate' children on English literacy measures, it might also be a methodological artefact in that the children classified as 'biliterate' were just more skilled at reading in English. The authors argued that Spanish decoding might not be an accurate reflection of levels of biliteracy, since Spanish and English are fairly similar in terms of the sound-letter relationships, so that monoliterate children with sufficient oral skills in Spanish could quite easily figure out how to read the Spanish words and thus, would be unjustly classified as biliterate. In a later study with a similar sample of Spanish-English bilingual children, Leider, Proctor, Silverman and Harring (2013) used both word decoding and reading comprehension in Spanish as an index of biliteracy. Results showed no contributions of biliteracy to measures of reading comprehension in English after accounting for age, English decoding abilities, and English and Spanish language skills. Although biliteracy was determined by considering both word reading and reading comprehension skills in Spanish, overall literacy levels in Spanish were very low since none of the children received any academic instruction in Spanish. Moreover, biliteracy was treated as a categorical variable in the analyses. Thus, the overall low literacy skills of the bilingual children in Spanish and the use of biliteracy as a binary variable might have prevented the authors from detecting any significant effects of biliteracy. Studies, like the ones by Proctor and Silverman (2011) and Leider et al. (2013), demonstrate the challenge in operationalizing constructs like bilingualism and biliteracy in an appropriate manner. Hence, future research would benefit from continuous measures of biliteracy to account for the large within-group variation, as well as from assessments that tap biliteracy as a single outcome (Proctor & Silverman, 2011). Taken together, the review of the existing literature suggests that a more systematic investigation of biliteracy might offer further insights into the interactions between bilingualism, language development, and cognitive abilities.

1.5 Summary & research questions

Bilinguals comprise a variety of speakers with different language experiences and levels of proficiency. There are many internal and external factors that influence bilingual language development and variables related to input and exposure have been shown to be particularly crucial in determining language outcomes. Moreover, the various internal and external factors do not affect all linguistic domains to the same degree which leads to bilingual profile effects where some domains tend to be more vulnerable than others. The general pattern that has emerged from the relevant research is that vocabulary skills tend to show the largest bilingualism effects, minimal or no effects are observed for basic literacy skills, and intermediate effects for linguistic comprehension, morphosyntactic development and reading comprehension. Moreover, bilingualism interacts with language dominance (i.e., input patterns) so that the stronger language of bilinguals (typically the majority language) is less influenced by bilingualism and the reduced amount of input associated with it. For morphosyntactic development, the impact of bilingualism is further mediated by the structural difficulty with complex structures being more likely to be delayed in bilingual acquisition than simple structures. In general, the size of the difference between monolinguals and bilinguals in terms of oral language skills is highly dependent on the measure used. Asymmetries in bilingual performance also emerge in the domain of narrative skills, where microstructure measures appear to be more influenced than macrostructure measures. Unlike morphosyntax, the factor that determines the size of the effect across different narrative sub-skills is not difficulty, but rather to what extent a given measure taps language-specific knowledge or skills. The notion of bilingual profile effects can also be applied to executive function skills. It has been argued that bilingualism confers advantages in certain aspects of cognitive control. However, the claim that bilinguals exhibit superior executive function has recently been challenged due to the highly inconsistent findings across studies, as well as methodological issues in previous studies. Given the finding that the linguistic profiles of bilinguals might differ as a function of language status (minority vs. majority language) and language-specific properties, as well as and the highly inconsistent results regarding bilingual advantages in executive control, further research is warranted. The present study sought to add to the existing literature by examining the linguistic and cognitive profiles in a sample of Greek-English bilingual children residing in the UK. The first two research questions are:

RQ1: What are the strengths and weaknesses of Greek-English bilingual children in the domains of language, literacy, and cognition?

RQ2: How does the bilingual children's performance in the minority language compare to performance in the majority language?

Research on the development of literacy skills in monolingual and bilingual children generally supports the Simple View of Reading which postulates decoding skills and linguistic comprehension as the two basic component skills of reading comprehension. Moreover, there is a wide consensus that the acquisition of word reading skills in alphabetic languages is heavily dependent on phonological processing abilities. Nevertheless, studies looking at predictors of literacy abilities in monolingual and bilingual children have produced inconsistent findings both within and across languages. Crosslinguistic differences have been typically attributed to the fact that orthographies vary in the consistency of letter-sound mappings. Another source of variation between studies is how the particular constructs and skills are measured. Despite the large body of research investigating reading development in monolingual and bilingual children, there is a dearth of studies that provide simultaneous comparisons between groups and languages. The current study addressed this issue by assessing Greek-English bilingual children on language and literacy measures in both of their languages, as well as by including a monolingual control group in each language. Hence, the third research question in this study is:

RQ3: What are the predictors of word decoding and reading comprehension skills in monolingual and bilingual children in English and Greek?

Many studies have examined the relationship between oral proficiency, cognitive abilities, and literacy skills in the two languages of bilinguals, but only a handful have tried to address the possibility of biliteracy effects directly. Because literacy is such a complex construct, it is not clear how it should best be measured and there is currently no commonly-used measure of biliteracy. Previous research on biliteracy has mainly focused on crosslinguistic relationships that would indicate transfer of skills, but only few have looked at how accumulating literacy skills in two languages might foster oral language or literacy skills – and these have typically used group designs, i.e., monoliterate vs. biliterate bilinguals. The present study set out towards filling this gap by using different indices of biliteracy to look at its relationship with oral language skills. The fourth research question is thus:

RQ4: Does biliteracy contribute to oral language skills in the two languages of bilinguals?

The possible advantage in executive function abilities conferred by bilingualism has been the subject of much controversy during recent years. Many studies that have reported superior performance on part of bilinguals compared to monolinguals on a range of tasks tapping executive function skills. However, there is also an increasing number of studies that fail to find evidence for such a bilingual advantage and there are aspects of bilingualism that remain underexplored. One of these aspects of bilingualism is biliteracy. While earlier studies did not consider literacy abilities of the bilinguals in their samples, recent evidence suggests that biliteracy is associated with enhanced executive function skills. As such, it is possible that biliteracy rather than bilingualism drives the bilingual advantage in cognitive control. The present study explores this idea by using different indices of biliteracy to look at its relationship with performance on a range of executive function measures. Accordingly, the fifth research question asks:

RQ5: Are there any effects of biliteracy on executive function skills in bilingual children?

The current study is unique in that it provides a comprehensive assessment of language, literacy, and cognitive skills of bilingual children speaking English and Greek, which is a relatively understudied language pair. As the Greek community in the UK is growing, it is important to understand how language, literacy, and cognitive skills interact and develop in this group of children in order to promote optimal outcomes in both languages. Moreover, English and Greek provide an interesting comparison because of differences in orthographic consistency which have been shown to influence reading development. In addition, the comprehensive assessment of the bilingual children’s language and literacy abilities together with monolingual comparisons in English and Greek allow for a more in-depth investigation of the skills underlying the reading processes in each language and their interactions.

CHAPTER 2 – METHOD

2.1 Participants

A total of 174 seven to twelve year old children from grades 3–6 participated in the study. The sample comprised 50 Greek-English bilingual children aged 7;3–12;3 (*M*=9;9, *SD*=1;4; 21 boys), 58 English monolingual children aged 7;6–11;5 (*M*: 9;4, *SD*: 1;1; 24 boys) and 66 Greek monolingual children aged 8;0–12;7 (*M*: 10;4, *SD*: 1;2; 30 boys). The two monolingual control groups were included as a reference point to put the bilingual children's overall performance in the two languages into a wider context. All of the bilingual children were residing in the UK at the time of testing and attended either a mainstream primary school (n=37) or the Greek primary school in London (n=13). The English and Greek monolingual children (henceforth L1-English and L1-Greek) were drawn from mainstream primary schools in South England and Northern Greece, respectively. None of the children had any reported learning or language difficulties, hence all were assumed to be typically developing. The following sections provide a comparative overview of the group characteristics as well as information on the recruitment procedure.

2.1.1 Age

An overview of the ages of the two monolingual control groups and the Greek-English bilingual children for each Year group is given in Table 1. The means indicate that the Greek monolingual children in all four Year groups were on average one year older than the bilinguals and the English monolinguals. This is because children in Greece enter the school system one year later than children in the UK. Thus, a two-way ANOVA on age with group (bilingual, L1-English, L1-Greek) and Year group (3, 4, 5, 6) as between-subjects factors was run to test whether the three groups differed in age. Results showed significant main effects of grade ($F(3,162)=496.45$, $MSE=20.4$, $p<.001$, $\eta_p^2=.902$), and group ($F(2,162)=106.68$, $MSE=20.4$, $p<.001$, $\eta_p^2=.568$), but no interaction ($F(6,162)=1.53$, $MSE=20.4$, $p=.171$, $\eta_p^2=.054$). Post hoc comparisons with Bonferroni corrections revealed that the main effect of group in Year 3, 4, and 5 was driven by the Greek monolinguals who were significantly older than the other two groups (all *p*s<.001). However, for the Year 6 children, the English monolinguals were significantly younger than the bilinguals[7] ($p=.006$) and both groups were significantly younger than the Greek monolinguals (both *p*s<.001). The boxplot for age in months per group and Year level is included in Appendix A. In order to account for the differences in age between the groups, age was added as a covariate in the analyses where appropriate.

[7] The children in this year group were slightly older than is usual for the education system in the UK. This is because five of the eleven Year 6 children came from the bilingual school in London which follows the Greek education programme where children tend to start primary school one year later than children in the UK.

Table 1. *Overview of ages (n, mean, SD and range) for the four Year groups of the Greek-English bilingual children and the two monolingual control groups.*

		Bilinguals	**L1-English**	**L1-Greek**
Year 3	*n*	13	12	15
	mean	8;1[a]	8;0[a]	8;9
	SD (in months)	4.4	3.6	4.1
	range	7;3-8;8	7;6-8;5	8;0-9;2
Year 4	*n*	9	21	19
	mean	9;1[b]	9;1[b]	10;0
	SD (in months)	5.8	3.9	3.5
	range	8;5-10;1	8;3-9;5	9;6-10;5
Year 5	*n*	17	13	19
	mean	10;1[c]	10;1[c]	10;10
	SD (in months)	4.8	4.7	3.4
	range	9;6-10;9	9;2-10;7	10;5-11;4
Year 6	*n*	11	12	13
	mean	11;6	10;10	12;0
	SD (in months)	4.0	3.6	4.3
	range	11;0-12;3	10;5-11;5	11;5-12;7
Group total	*n*	50	58	66
	mean	9;9	9;4	10;4
	SD (in years)	1;4	1;1	1;2
	range	7;3-12;3	7;6-11;5	8;0-12;7

Note. Means sharing the same superscript are not significantly different from each other.

Table 1 indicates that the children in each language group were unevenly distributed across the four Year groups. In the bilingual group, there were more children from Year 5 than from the other grades, while the English monolingual sample comprised more children from Year 4. In the L1-Greek sample there were slightly more children in Year 4 and 5 compared to Year 3 and 6. However, inspection of the histograms of the children’s ages for the three groups suggested that overall the children in the three groups were evenly distributed across the age range tested (see Appendix B).

2.1.2 Socioeconomic background (SES)

Research has shown that there is a strong association between socioeconomic status (SES) and child development with higher SES leading to better outcomes (Bradley & Corwyn, 2002). More specifically, socioeconomic background plays a major role in children’s academic achievement (Sirin, 2005) with robust effects being reported for measures of general intelligence (Capron & Duyme, 1989), as well as for measures of language development

(Arriaga, Fenson, Cronan & Pethick, 1998; Hoff, 2003). Thus, it is important to consider the socioeconomic background of the monolingual and bilingual participants to ensure that the results are not confounded by differences in SES. Although measures of household SES have typically taken into account parents' level of income, education and occupation in combination (White, 1982), more recent studies tend to use maternal education alone as a proxy for socioeconomic status (e.g., Hoff, 2003; Hoff & Tian, 2005). This is because parental education is more stable over time than, for example, family income (Huston, McLoyd & Coll, 1994), and because information about educational levels is more straightforward to measure than a family's income (Hauser, 1994). For the bilinguals, information about SES was obtained by means of a parental questionnaire (see Appendix C). SES was calculated on the basis of the mother's highest level of education and consisted of a 5-point scale: 1- primary education, 2- compulsory secondary education, 3- upper secondary education, 4- professional training, and 5- tertiary education. Overall, the mothers of the participating bilingual children were highly educated with an average score of 4.71 (*SD*=0.62) on the 5-point education scale. Four mothers (8.3%) were educated up to upper secondary school level, six mothers (12.5%) reported professional training as their highest level of education and the remaining 38 mothers (79.2%) all had reached tertiary education. Unfortunately, the questionnaire did not provide a more fine-grained differentiation within the level of tertiary education (i.e., Bachelor's degree, Master's degree, doctoral degree etc.). Based on the high level of education on part of the mothers, the current bilingual sample is best characterized as coming from upper middle class families.

In contrast to the bilingual participants, no background information was obtained from the parents of the monolingual children about their home environment or the socioeconomic status of their families. However, it is possible to derive socioeconomic status on the basis of participants' postcodes of residence at recruitment (e.g., Woodward, 1996). The Office for National Statistics has produced model-based estimates of average household incomes for England for 2007/8[8]. Income estimates are given for smaller local areas as assigned by postcodes with the estimates divided into five income levels. Inspection of the map showed that all UK participants (i.e., the bilinguals and the English monolinguals) came from households residing in areas at the two highest levels of income. Thus, it was concluded that the Greek-English bilinguals and the English monolinguals were matched on socioeconomic background. Unfortunately, there are no similar income statistics available for Greece. However, the schools from which the Greek monolinguals were recruited were all located in the more affluent parts of a large Northern city which makes it unlikely that the sample included children with low SES. Thus, despite the lack of a more explicit comparison with the other groups, it was assumed that the Greek monolinguals were from similar socioeconomic backgrounds as the bilingual and the English monolinguals, namely from middle and upper middle class families.

[8] http://www.neighbourhood.statistics.gov.uk/HTMLDocs/incomeestimates.html

2.1.3 Recruitment

The participants were recruited through a variety of sources. The majority of the bilingual children (n=28) were recruited from Greek Saturday schools (one in Reading, one in Oxford and three in London). First, one of the researchers contacted the head teacher to obtain permission to visit the school to inform the parents. On visiting the schools, the experimenters introduced themselves to the parents and distributed the relevant information sheets. The parents who were willing to participate either left the researchers their contact details or got in touch with the researchers themselves in order to arrange the appointments. Another 13 bilingual children were recruited from the Greek–English bilingual school in London. After obtaining permission from the head teacher, letters were sent out to the parents of all the children from Years 3–6. Only children who returned the signed consent form from their parents participated in the study. The remaining nine bilingual children were recruited through word of mouth in that some parents of the participating children passed on the information to friends who then got in touch with one of the researchers if they were willing to take part. Approximately half of the L1-English participants (n=27) were recruited from two (mainstream) primary schools in Reading. After obtaining consent from the head teacher to conduct research at their school, a number of children from Years 3–6 were randomly selected and given written information for their parents. Only children who returned the consent form signed by their parents were allowed to take part in the study. About a quarter of the L1-English sample (n=14) was recruited via an infant research panel that is organised and administered by the Child Development Group of the Psychology department at Reading University. The database was searched for children who met the criteria (i.e., typically developing English monolingual children from Years 3–6, thus aged between 7;0 and 11;6) and their parents were contacted via email or telephone. If the parents agreed to participate in the study, an appointment was arranged. Another eight children were recruited by sending out emails to academic staff of the department to locate children in the targeted age range whose parents are happy for them to participate. The remaining nine children from the L1-English control group were recruited through word of mouth, i.e., parents of participating children offered to pass on information about the study to friends who then contacted one of the researchers if they were willing to participate. Finally, the L1-Greek children were recruited from four different (mainstream) primary schools in Thessaloniki, Greece. The head teachers were again approached to obtain consent to carry out the research before sending letters to the parents of a number of randomly selected children from Years 3–6. As with all the participants, only children whose parents had given written consent were included in the study.

2.2 Profile of the bilingual participants

As mentioned in the introduction, this study took a broad approach to bilingualism with regard to the conditions in which the children were acquiring or had acquired the two languages. While this approach naturally introduces a high level of variability among the language profiles of the children, it ensures that the sample is representative of the general Greek-English bilingual population in the UK. Thus, the advantage of including heterogeneous bilingual samples in group comparisons with monolinguals is that the results indicate fundamental differences between groups that are broadly generalizable (see chapters 3 and 4). On the other hand, in order to account for the enormous individual variation in language abilities inherent in the bilingual population, it is necessary to treat bilingualism as a continuous variable. However, there is no consensus in the field with regard to the particular variable on which the bilingual continuum should be based on. Accordingly, researchers have used a variety of different measures of bilingualism, with many relying on input-related variables such as home language use, age of onset or length of exposure, and the like. By using gradient measures of bilingualism, it is possible to pinpoint the relevant dimensions of the bilingual experience that influence linguistic and cognitive development. The current study used detailed parental questionnaires to elicit background information on the children's home and school environment. The majority of the information was used for descriptive purposes only. This is because the instrument was a general-purpose questionnaire that covered multiple aspects of the children's language environment in varying levels of detail. Given that the focus of the current study was biliteracy, the main exposure-related variable of interest was the amount of schooling the children had received in each language (see chapters 5 and 6). Children spend large amounts of time at school, so language input within the educational context is at least as important as language use at home.

The questionnaire used in the current study was developed within a larger project on bilingual language acquisition and education (BALED[9]) and covers several areas, namely (i) parents' language ability and use, (ii) the child's use of different languages, (iii) acquisition and development of the child's language ability in English, (iv) acquisition and development of the child's language ability in Greek, (v) the child's knowledge and use of other languages, (vi) difficulties with the child's language development, and (i) demographic information (see Appendix C, for full questionnaire). The variables that were extracted from the questionnaire included age, place of birth, age of arrival in the L2 community (i.e., the UK), mother's education (as an index of socioeconomic status), home language history, age of onset of

[9] This was a Thales project entitled "Bilingual Acquisition & Bilingual Education: The Development of Linguistic & Cognitive Abilities in Different Types of Bilingualism" which was funded by the European Social Fund and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF). http://www.enl.auth.gr/langlab/thalis_en.html

exposure, current language use and exposure, children's language proficiency in the various languages, as well as literacy practices at home and amount of formal instruction in each of the languages. Parents were asked to fill in the questionnaires at their convenience and return them to one of the experimenters. Questionnaires were obtained for all but two children. Thus, all of the descriptions in this section (2.2) are based on 48 bilingual children.

2.2.1 Place of birth & age of arrival

The majority of the children was born in the UK (n=29) while the remaining children were born in Greece (n=18) apart from one child who was born in Spain. The age of arrival in the L2 community for those children who were born elsewhere than the UK ranged from 2;6 to 11;0 years (*M*=7;0, *SD*=2;4). Figure 1 shows the spread of the ages at which the 19 non-UK born children arrived in the UK. There were eight bilingual children whose age of arrival was 6 years or younger and eleven children moved to the L2 community after the age of 6. In terms of time of residence in the UK, seven of the eleven children who arrived after the age of 7 had been in the UK for less than 2 years, while the remaining four children had lived in the L2 community for 2 to 4 years at the time of testing. The two children with the earliest age of arrival (2;6 and 4;0 years) had been living in the UK for over 5 years whereas for the six children whose age of arrival was between 4–6 years old, the length of residence in the L2 community at the time of testing was 2–3 years.

Figure 1. Distribution of age of arrival in the UK for the 19 bilingual children who were not born in the UK. Each circle represents one child (n=19).

2.2.2 Language input & use

The questionnaires covered various aspects of language use such as the age at which children started to be systematically exposed to the two languages, the languages spoken between the child and other family members, knowledge and use of other languages, as well as the child's oral proficiency in the various languages as perceived by their parents. With regard to age of onset of systematic exposure to English and Greek, all of the children were exposed to Greek from birth by way of having at least one Greek-speaking parent. More specifically, 33 of the bilingual children were from families with two Greek-speaking parents with the majority (n=27) using predominantly Greek in the family, while for the remaining six children parents reported frequent use of both Greek and English in the home. Ten children came from mixed marriages where one parent was a native speaker of Greek and the other a native speaker of English. In these cases, it was typically the mother who was a native speaker of Greek, while the father was speaking English, except for one case where it was the other way round. The sample also included five children who were actually trilingual. Three of the five children had a Greek-speaking mother while their father spoke a language other than English or Greek (namely, German, French or Portuguese), one had a Spanish-speaking mother and a Greek-speaking father and one child had Greek-French-English trilingual parents. Despite being trilingual, the five children were included in the present study given that English and Greek were the two stronger languages of the children, while proficiency in the third language was either lower (n=3) or on a par with the other languages (n=2)[10]. In terms of the start of systematic exposure to English, 22 children (all UK born) were exposed to English from birth and for seven children (4 UK and 3 non-UK born) this happened between 1–3 years old, typically through English-speaking childcare. For eight of the children (3 UK and 5 non-UK born), systematic exposure to English started between the ages of 4–6 when they entered kindergarten or preschool where English was the medium of instruction. For the remaining eleven children (all non-UK born), systematic exposure to English started after the age of 6.

An index of language history (i.e., early language input) that considered sources of language input before the children started formal literacy education (i.e., before age 4 in the UK and before age 5 in Greece) was calculated on the basis of the questionnaire variables. The possible sources of language input that were taken into account to derive this index were 1) the language the mother used with the child, 2) the language the father used with the child, 3) the language of any additional childcare outside the home/family, and 4) the language of the community the child was living. Each of these potential sources of input was weighted equally and language input from the parents was assumed to be stable over the years. Next, the percentage of input in English, Greek and any other language was calculated for each year separately (i.e., 0–1 years, 1–2 years, 2–3 years, 3–4 years, and if the children were living in Greece also 4–5 years[11]). The last step was to calculate the average percentage of relative amount of input for each language collectively over the 4 or 5 years before the child started formal literacy education. Table 2 presents the average percentage of early language input in English, Greek and any other languages for the bilinguals before the start of formal education. As a group, the bilinguals had significantly more input in Greek than in English ($t(47)=2.72$,

[10] Although these children are included with the bilinguals, the use of the third language was taken into consideration in the calculation of the various measures of exposure.

[11] For children living in Greece, years 4–5 were included given that primary education in Greece starts one year later than in the UK.

p=.009, *d*=0.39) although there was considerable variation as the relatively large *SD*s show. The variability in the relative amount of input in Greek and English is further illustrated in Figure 2. There were twelve children who were exposed exclusively to Greek during the first 4–5 years of their life, and another four children who had predominantly Greek exposure (80–100%) and relatively little exposure to English or any other languages (<20%). For six children, input in Greek was roughly twice as much as in English, and for ten children it was the other way round with input in English being about twice as much as input in Greek. For nine children, the relative amount of input was roughly equal across Greek and English (i.e., less than 20% difference between the two languages) and six children had received very little input in Greek during early childhood (<20%). Thus, on the basis of the exposure patterns during early childhood, 22 children would be classified as Greek-dominant, 16 as English-dominant and the remaining nine children as balanced.

Table 2. *Relative amount of early language input in the various languages.*

	% Greek	**% English**	**% Other**
mean	59.8	36.7	3.5
SD	30.1	29.7	9.9
range	15.6-100	0-84.4	0-58.3

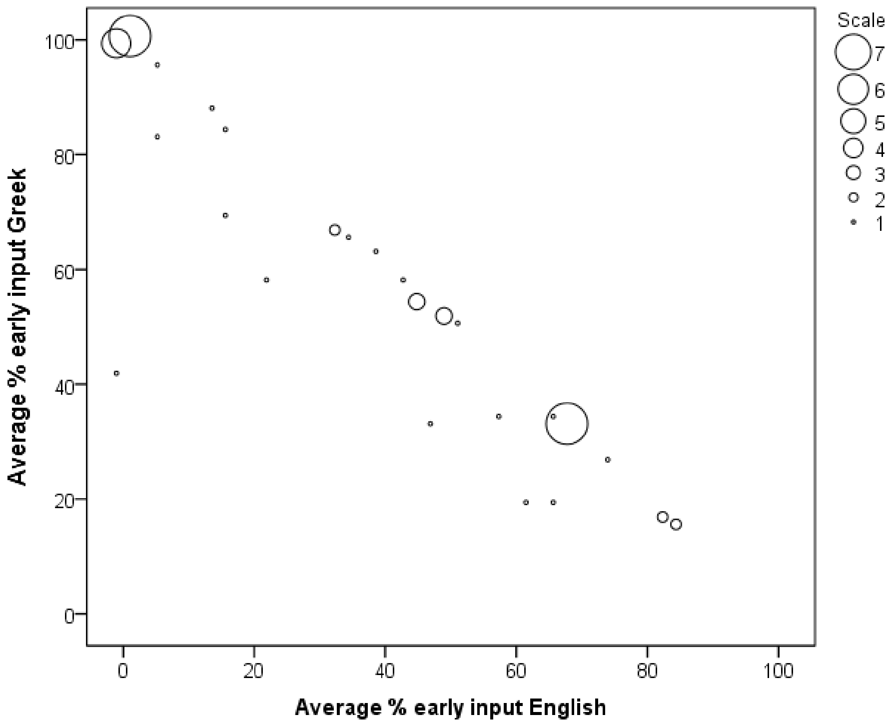


Figure 2. Relative amount of exposure to Greek and English during early childhood (n=48).

The calculation of current amount of exposure was based on eight questionnaire items that provided information on the child's language use with members of the family (mother, father, siblings, Greek relatives) and with friends (school friends, family friends), as well as the language spoken between the parents. For seven of the items, parents had to indicate the relative frequency of use of the various languages on a scale from 1 to 5 (1- English only; 2- more English than Greek; 3- both languages equally often; 4- more Greek than English; 5- Greek only). The point scores were subsequently converted into percentage scores for the various languages, e.g., a point score of 1 corresponded to 100% English and 0% Greek, a point score of 2 yielded 75% English and 25% Greek, a point score of 3 was noted as 50% English and 50% Greek, etc.)[12]. The 8th item that was included in the index for current amount of exposure concerned the origin of the child's friends, i.e., whether the child's friends were mainly children from Greece, the UK, or other countries. If the child's friends were mainly children from the UK and/or other countries, the item was scored with 100% English and 0% Greek, if the child's friends were mainly Greek children it was scored as 0% English and 100% Greek and if the child had friends both from Greece and the UK the score was divided resulting in 50% English and 50% Greek. After converting the individual questionnaire items into percentage scores, the total percentage of language input in each language could be calculated across the eight items. The overall group average appeared to show that the relative amount of current language input was numerically higher in Greek than in English (see Table 3). However, a paired samples *t*-test showed that this difference was not statistically significant ($t(47)=1.77$, $p=.083$, $d=0.26$). There was a lot of variation across the sample and a roughly even distribution of current amount of input, as illustrated in Figure 3. More specifically, there were eleven children with 80-100% current input in Greek and 0–20% input in English, nine children with 60–80% Greek vs. 20–40% English, 16 children in the middle range with 40–60% in each language, nine with 20–40% Greek vs. 60–80% English and three children with 0–20% Greek vs. 80–100% English. For the five trilingual children, current amount of input in the third language was very low (<8%) except for one child whose current input was relatively balanced across the three languages (25% English vs. 37.5% Greek vs. 37.5% Spanish).

Table 3. *Relative amount of current exposure in the various languages.*

	% Greek	**% English**	**% Other**
n	48	48	5
mean	55.5	43.2	9.3
SD	24.4	23.8	12.6
range	4.7-100	0-89.1	3.1-37.5

[12] For the trilingual children, amount of input in the third language was also taken into account in the calculation of the percentages for English and Greek.

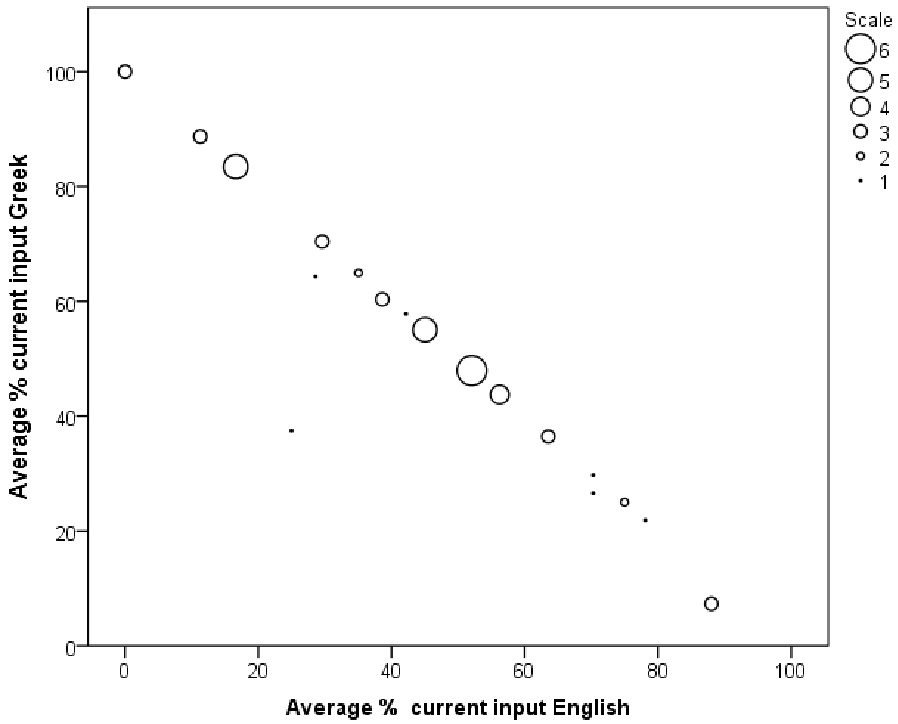


Figure 3. Relative amount of current exposure to Greek and English (n=48).

Another variable that was extracted from the questionnaires was the child's daily use of the various languages in terms of frequency. Parents had to indicate how often the child communicates in different languages every day based on a scale from 1 to 5 (1- not at all; 2- rarely; 3- sometimes; 4- often; 5- very often). On average, the children used more English than Greek or any other language they spoke (see Table 4). Paired samples *t*-tests showed that the difference in daily use between Greek and English was significant ($t(47)=3.86$, $p<.001$, $d=0.62$), as was the difference between English and any other language ($t(47)=20.75$, $p<.001$, $d=3.03$), and between Greek and any other language ($t(47)=14.02$, $p<.001$, $d=2.01$)[13]. There were 23 children who used more English than Greek and 19 who used the languages equally often on a daily basis. The remaining six children conversed more in Greek than in English throughout the day[14].

[13] The analyses were repeated using the Wilcoxon signed-ranks test given that the data were ordinal. The results using the non-parametric test remained the same (English vs. Greek: $Z=-3.48$, $p<.001$; English vs. other: $Z=-6.16$, $p<.001$; Greek vs. other: $Z=-5.83$, $p<.001$).

[14] All six children were attending the Greek school in London and four of them had been in the UK for less than 2 years which explains the more frequent use of Greek than English.

Table 4. *Scores for children's daily use of Greek, English, and any other language.*

	Greek	**English**	**other language** *full sample (n=48)*	**other language** *trilinguals (n=5)*
mean	4.2	4.9	1.5	3.4
SD	0.97	0.36	1.03	1.34
range	1-5	4-5	1-5	2-5

Parents were also asked to rate their children's proficiency in terms of oral skills in the various languages on a scale from 1 to 5 (1- not at all; 2- a little; 3- adequately; 4- well; 5- very well). As a group, there was no difference between reported oral language skills across the two languages (see Table 5) which was confirmed by a series of paired samples *t*-tests (understanding speakers: $t(47)=1.48$, $p=.146$, $d=0.13$; understanding TV: $t(47)=-.0.30$, $p=.767$, $d=0.04$; speaking: $t(47)=-1.18$, $p=.242$, $d=0.21$)[15].

Table 5. *Scores for children's listening (speakers and TV) and speaking skills in Greek and English as rated by their parents.*

	Understanding speakers		**Understanding TV**		**Speaking**	
	Greek	*English*	*Greek*	*English*	*Greek*	*English*
mean	4.8	4.7	4.7	4.7	4.5	4.7
SD	0.43	0.56	0.63	0.58	0.71	0.55
range	3-5	2-5	3-5	3-5	3-5	3-5

The analyses of the questionnaires showed that in general, the bilingual children show a lot of variability in terms of language experience and home environment. Consequently, the sample includes children at both ends of the spectrum (extensive input in Greek and little input in English vs. little input in Greek and extensive input in English) with a roughly even distribution of children along the whole spectrum. As such, the present sample of bilingual children nicely illustrates the need to treat bilingualism as a continuous variable rather than a categorical one (see Luk & Bialystok, 2013).

2.2.3 Literacy

Using the data obtained from the questionnaires, an index of amount of formal schooling (English, Greek, total) as well as the relative amount of schooling in English and Greek could be calculated. After inspecting timetables for Greek and English primary schools on the internet, it was determined that for mainstream primary schools in England and Greece, an average week

[15] Because the data are ordinal, the analyses were re-run using the Wilcoxon signed-ranks test. The results for the non-parametric tests did not show any differences between reported oral skills in English and Greek (understanding speakers: $Z=-1.45$, $p=.147$; understanding TV: $Z=.0.17$, $p=.867$; speaking: $Z=-1.29$, $p=.199$).

consists of 25 hours of formal instruction. For the Greek school in London, the week comprises 26 hours of formal instruction whereby 21 hours are taught in Greek and 5 hours are taught in English. The next step was to combine the information from the questionnaires where the parents indicated in which countries the children had received formal schooling and the types of schools they had attended, as well as information about amount of additional instruction in Greek or English via private lessons or Saturday schools. For each language, the number of hours of schooling per week was then multiplied by the number of years a child had received this particular type of schooling to derive an index for Greek and English schooling. For example, child A had completed 3 years of schooling in Greece (3*25) before moving to the UK where he/she has been attending a UK primary school for 1.5 years (1.5*25), but continued to receive Greek instruction through weekly lessons (3 hours per week) at a Greek Saturday school (1.5*3). Hence, the index for Greek schooling for that child amounts to 79.5 (3*25+1.5*3) and the index for English schooling is 37.5 (1.5*25). The sum of the two indices for Greek and English schooling formed the index for total amount of schooling. Thus, the index of total amount of schooling for child A is calculated as 3*25+1.5*25+1.5*3=117. The three indices could then be used to calculate the percentage of schooling received in each language separately, which in the case of the hypothetical child A would be 68% in Greek (3*25+1.5*3=79.5 and 79.5/117*100=68%) and 32% in English (1.5*25=37.5 and 37.5/117*100=32%). The average group values for the schooling indices and the relative amount of schooling in English and Greek are given in Table 6. There was one child who had received formal schooling in another country than England and Greece (English: 61%, Greek: 14%, Spanish: 25%)[16]. Overall, the relative amount of schooling for the bilingual children was higher in English (63%) than in Greek (36%). A paired samples *t*-test showed that this difference was significant ($t(47)=2.65$, $p=.011$, $d=0.38$). As Figure 4 shows, the distribution was quite tail-heavy, i.e., there were many children at the low and high ends, while only a few had received roughly equal amounts of formal schooling in the two languages. The majority of the children had received schooling almost exclusively in English with only minimal formal instruction in Greek (80–100% English and 0–20% Greek, $n=26$). Three children had received 20–40% schooling in Greek with 60–80% in English, and three children had undergone roughly equal amounts of formal schooling in the two languages (40–60% each). For four children amount of schooling was between 20–40% in English and 60–80% in Greek, and the remaining twelve children had received between 0–20% formal instruction in English and 80–100% in Greek.

[16] The amount of formal schooling in the third language was included in the index for total amount of schooling for this child.

Table 6. *Scores on schooling indices and relative amount of schooling in Greek and English.*

	Index total schooling	Index Greek schooling	Index English schooling	% Greek schooling	% English schooling
Mean	128.7	48.2	79.6	36.3	63.2
SD	33.5	50.9	51.4	35.3	35.2
Range	59-189	1.5-156.5	7.5-175	1.7-95.4	4.6-98.3

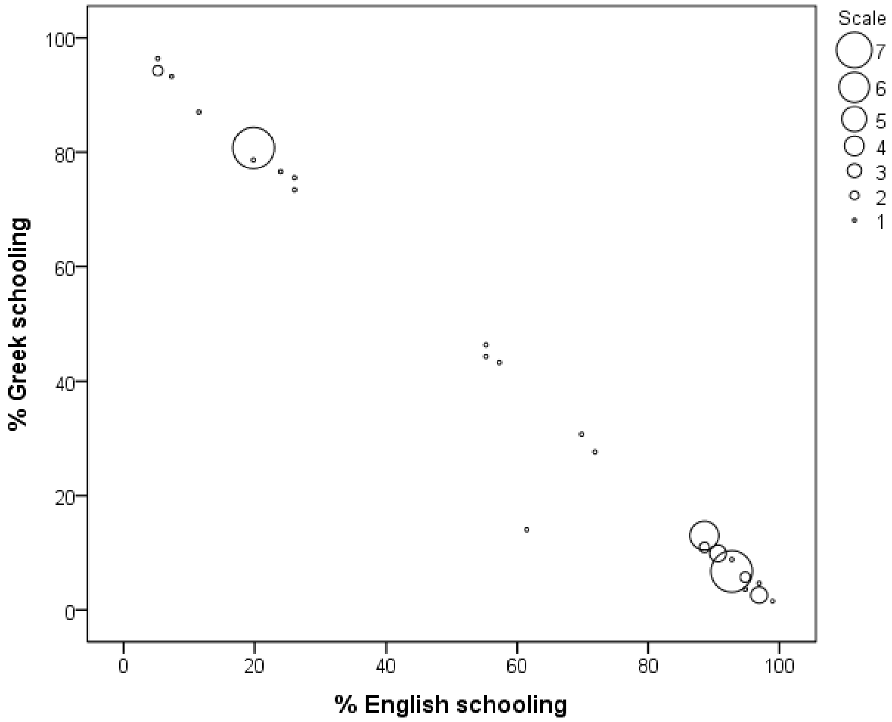


Figure 4. Relative amount of formal schooling received in Greek and English (n=48).

The second index of literacy that was derived from the questionnaires concerned literacy practices at home (Home Literacy Index, HLI). For this index, it was considered whether somebody helps or used to help the child with his/her homework and if yes, in what language this happens or used to happen. The index also took into account parental efforts to support the child’s language and literacy development by reading to them or encouraging them to read books in the two languages. This information was elicited in seven questionnaire items that each carried 1 point. Children’s computer use at home was also included in the HLI. If the child spent more than one hour per day at the computer, they got 2 points. If they used the computer for less than one hour per day, they got 1 point, and if parents stated that the child does not use a computer at home, they got 0 points. The parents also indicated what language was used when using the computer, although points were only given to a particular language if the parents indicated that it was used ‘often’ or ‘very often’, but not if they indicated that they used the language ‘sometimes’ or ‘rarely’. If the children used more than one language on the computer, the points were split across the particular languages provided they used them ‘often’ or ‘very often’. For example, a child that used the computer for 1.5 hours a day got 2 points for computer use. If it often used it in English and only rarely in Greek, both points went to English. If however, the child used English very often on the computer, but often used Greek as well, the points were divided across the two languages. Thus, the HLI was composed of a maximum of 9 points that were divided across the two languages accordingly. The mean scores for total HLI and HLI in Greek and English as well as the distribution across languages in percent is given in Table 7. The average score for the HLI total was 6.6 out of a maximum of 9 with a *SD* of 1.7 indicating that the bilingual children engaged in literacy-related activities at home to varying degrees. In terms of the language used during these activities, literacy practices were more frequently carried out in English than they were in Greek ($t(47)=5.46$, $p<.001$, $d=0.78$). Figure 5 shows the distribution of point scores for the HLI in English and Greek. Half of the children engaged in literacy related activities more often in English than in Greek (HLI English was higher than HLI Greek by 2 points or more). For 20 children, the literacy practices at home were evenly distributed across the two languages (HLI Greek and HLI English differed in point score by 1 point or less) and only four children reported more literacy practices in Greek than in English (HLI Greek higher then HLI English by 2 points or more).

Table 7. *Scores on home literacy index (HLI total, Greek, English) and relative amount of literacy practices in English and Greek.*

	HLI Total	**HLI Greek**	**HLI English**	**% Greek**	**% English**
mean	6.6	2.5	4.0	37.9	62.1
SD	1.67	1.27	1.29	16.6	16.6
range	2-9	0-5	1-6	0-75	25-100

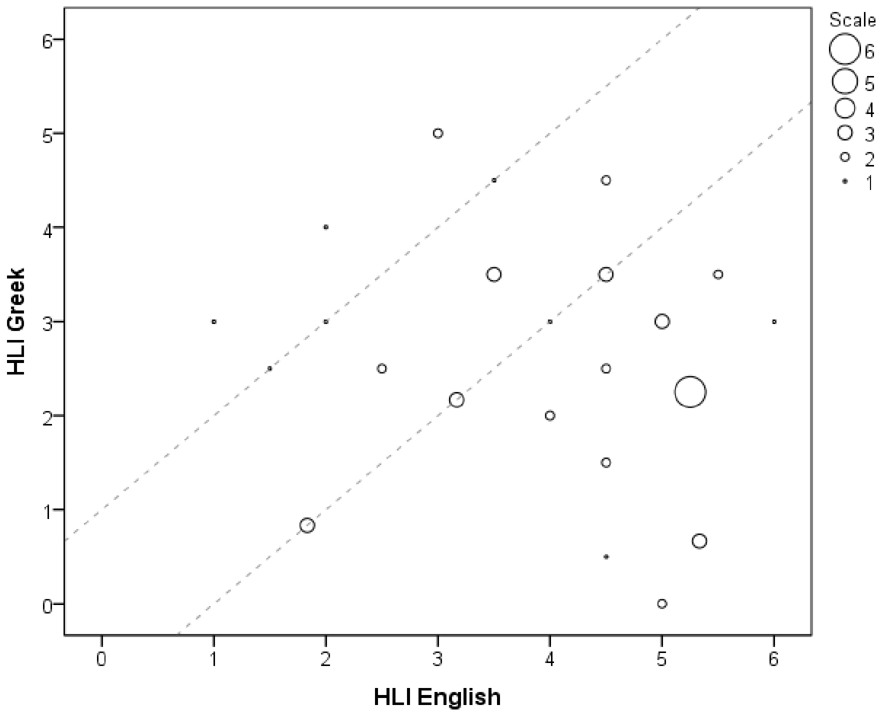


Figure 5. HLI in Greek and English (n=48). The two dotted lines indicate the area where the difference between HLI Greek and HLI English was 1 point or less.

Parents were also asked to rate the children's reading and writing skills in the various languages on a scale from 1 to 5 (1- not at all; 2- a little; 3- adequately; 4- well; 5- very well). Children's scores were higher in English than in Greek for both reading and writing skills (see Table 8). Paired-samples *t*-tests showed that the difference between languages was significant for reading ($t(47)=4.94$, $p<.001$, $d=0.71$) and writing ($t(47)=5.69$, $p<.001$, $d=0.82$)[17].

Table 8. *Scores for children's reading and writing skills in Greek and English as rated by their parents.*

	Reading skills		**Writing skills**	
	Greek	*English*	*Greek*	*English*
mean	3.9	4.7	3.7	4.6
SD	0.93	0.55	1.00	0.64
range	2-5	3-5	2-5	3-5

2.3 Tasks & Measures

The study aimed at providing a comprehensive assessment of the Greek-English bilingual children's language and literacy skills in both languages, as well as their cognitive abilities. To this end, the children were administered a range of tasks that were roughly divided into baseline

[17] The analyses were repeated with the Wilcoxon signed-ranks test for non-parametric data. The results remained the same in that reading and writing skills were significantly higher in English than in Greek (reading: $Z=-3.97$, $p<.001$; writing: $Z=-4.30$, $p<.001$).

measures, oral language measures, executive function measures and literacy measures. All of the verbal tasks came in two versions, one in English and one in Greek. Care was taken to make the tasks as similar as possible across languages. For some measures, the two versions were exact equivalents or translations of each other, while other tasks had the same format in the two languages, but used different stimuli due to language-specific properties. The following sections present the various tasks and measures in more detail.

2.3.1 Baseline measures

Three baseline measures were used to ascertain the children's non-verbal intelligence and expressive vocabulary skills in English and Greek. A measure of non-verbal intelligence was included to verify that the results of the analyses were not confounded by general ability. Similarly, the expressive vocabulary tests served as a baseline for children's level of language proficiency (or lexical skills) in the two languages and were used as control variables in the analyses.

Non-verbal Intelligence

Non-verbal reasoning (non-verbal IQ) was measured with the Raven's Coloured Progressive Matrices Test (CPM; Raven & Court, 1998). The test was developed to measure general ability in children aged 4 to 11 years in educational and clinical settings. The CPM consists of 36 perceptual and conceptual matching exercises that are divided into three sets of 12 items, whereby the items increase in difficulty within a given set. Each item presents a pattern with a piece missing and the task is to identify the correct answer out of six options. The items were presented in a booklet and children simply had to point to the correct alternative or say the corresponding number (see Appendix D, for example items). The raw score is the total number of correct items out of 36 and can subsequently be converted into a standard score with a mean of 100 and a standard deviation of 15. The test requires minimal verbal instructions and is viewed as a culture-fair measure of intellectual functioning (Kaplan & Saccuzzo, 2017). Normative data is available for children in the UK aged between 4 and 11 years, as well as for a number of other populations. However, there are no normative data on children from the same age range in Greece. Given that the test is claimed to be culturally neutral, the same UK normative data were used to calculate the standard scores for all the children in the present study (regardless of whether they were living in the UK or Greece).

English Vocabulary

Children's expressive vocabulary in English was measured with the Renfrew Word Finding Vocabulary Scale (Renfrew, 1995). The test was developed for use with children aged 3–8 years, and it consists of 50 black-and-white line drawings of objects (see Appendix E, for examples and the full list of items). The pictures were presented one-by-one on a computer laptop via a PowerPoint presentation with items arranged in order of difficulty. Subjects were asked to name each of the individual pictures (*What is this called?*) and children's spontaneous answers were recorded. The raw score is the total number of correct items out of 50. As the test is only standardized up to the age of 8;6, only raw scores could be used in the analyses[18].

Greek Vocabulary

To measure vocabulary in Greek, children were administered the Greek version of the Renfrew Word Finding Vocabulary Scale (Renfrew, 1995) which was developed by Vogindroukas, Protopapas and Sideridis (2009). The test uses the same picture stimuli as the Renfrew in English with the exception of two items which were replaced with a similar item appropriate for the Greek culture (English: steeple/spire -> Greek: trulos "dome" and English: cuff -> Greek: blusa "pullover", see Appendix F for the full list of items). Moreover, the original line drawing for the item *beehive/kipseli* was replaced with a picture that depicts a typical beehive in Greece. The correct answers for three items were extended to include another commonly used alternative (*kite*: chartaetos/**aetos**, *spanner*: galliko klidi/**kavuras** and *sling*: narthikas/**epidesmos**). Finally, the items in the Greek version were re-ordered by the test developers to reflect cultural differences from English in terms of level of difficulty of the individual items. As with the English version, the pictures were presented one-by-one on a computer laptop in a PowerPoint presentation and children were asked to name the pictures (*Ti ine afto?* "What's this?"). The raw score was the total number of correctly named items out of 50. Like the English version (the Renfrew), the Greek version is standardized up to the age of 8;6 so only raw scores could be used in the analyses.

2.3.2 Oral language measures

To measure children's oral language skills, a sentence repetition task and a narrative re-tell task were administered in both English and Greek. The tasks were used to assess different aspects of oral language skills, including knowledge and use of syntactic structures, ability to produce grammatically correct sentences, listening comprehension as well as narrative skills at the level of microstructure (i.e., syntactic complexity, verb diversity, length and grammaticality). The present section provides detailed descriptions of the two tasks and the various measures that were derived from them.

[18] Note that several other studies have used the Renfrew with older monolingual and bilingual children up to 12- years-old (e.g., Kaltsa, Tsimpli, Marinis & Stavrou, 2016; Schelletter & Parke, 2004).

Sentence Repetition Task in English and Greek

Both the English and Greek Sentence Repetition Tasks were developed within the COST Action IS0804[19] (LITMUS tools; Marinis & Armon-Lotem, 2015). In this task, children listen to a series of sentences and are asked to repeat them verbatim. The English Sentence Repetition Task (henceforth English SRT) comprised 30 sentences that contained a range of different grammatical structures. The five sentence types included in the English SRT and some examples are given in Table 9. There were six sentences for each sentence type. The full list of items can be found in Appendix G.

The Greek Sentence Repetition Task (henceforth Greek SRT) was slightly longer and consisted of 32 sentences. There were eight different sentence types in the Greek SRT with four sentences each. The eight sentence types of the Greek SRT and some examples are presented in Table 10. The full list of items can be found in Appendix H.

Table 9. *Sentence types used in the English SRT with examples.*

i.	**SVO with one or two auxiliaries/modals**
	e.g., The kitten could have hit the ball down the stairs.
ii.	**Passives: short actional and long actional and non-actional**
	e.g., The cow was kicked in the leg by the donkey.
iii.	**Object questions: who, what, which**
	e.g., Which picture did he paint at home yesterday?
iv.	**Sentential adjuncts: before/after/because and conditionals**
	e.g., The people will get a present if they clean the house.
v.	**Object relative clauses: right branching and centre embedded**
	e.g., The horse that the farmer pushed kicked him in the back.

[19] http://www.bi-sli.org/

Table 10. *Sentence types used in the Greek SRT with examples.*

i.	**SVO**
	e.g., Ο τουρίστας ξέχασε τον οδηγό των διακοπών στο σπίτι.
	"The tourist forgot the travel guide at home."
ii.	**Negation**
	e.g., Ο ζωγράφος θέλει να μην πιάνουν οι φίλοι του τους πίνακές του.
	"The painter does not want his friends to touch his paintings."
iii.	**Clitics: clitic doubling and clitic left dislocation**
	e.g., Την ταινία την είδε χτες ο δάσκαλος με τους μαθητές στο σινεμά.
	"The teacher watched the movie with his students at the cinema yesterday."
iv.	**Coordination**
	e.g., Ο χορευτής πήρε την ομπρέλα του και περπάτησε στη δυνατή βροχή.
	"The dancer took his umbrella and walked in the heavy rain."
v.	**Adverbial clauses**
	e.g., Ο γείτονας αγόρασε το αυτοκίνητο πριν πουλήσει το μικρό σπίτι.
	"The neighbour bought the car before he sold the little house."
vi.	**Wh- complement clauses**
	e.g., Μόνο ο αστυνόμος γνώριζε τι έκλεψαν από το σαλόνι οι ληστές.
	"Only the police officer knew what the burglars stole from the living room."
vii.	**Relative clauses: subject and object**
	e.g., Ο αστυνόμος είδε την κοπέλα που του είχε πουλήσει ένα παγωτό.
	"The police officer saw the girl who had sold him an ice-cream."
viii.	**Complement clauses**
	e.g., Οι νοσοκόμες είπαν ότι η πτήση του γιατρού έχει καθυστέρηση.
	"The nurses said that the doctor's flight is delayed."

Given the length of the sentences (on average 8.8 words in English and 10.4 in Greek), it is unlikely for the children to simply reproduce the sentences from short-term memory without successful comprehension (Vinther, 2002). Thus, the task requires the children to process the sentence in order to derive its meaning before reproducing the sentence from long-term memory (Potter & Lombardi, 1990). As such, Sentence Repetition Tasks can be used to measure oral language skills and more specifically, grammatical abilities. In other words, the assumption is that if a child has not (yet) acquired a particular grammatical structure, s/he will not be able to successfully reproduce it in a Sentence Repetition Task. The administration procedure for both the English and the Greek SRT was the same. The sentences were pre-recorded by a native speaker of English and Greek, respectively, and were embedded into a PowerPoint presentation. The task was masked as a game named "The Treasure Hunt" featuring a bear named Teddy. Children were seated in front of a computer laptop and were given a set of headphones to prevent any noise disruptions. They were told that in order to follow Teddy on his treasure hunt, they had to listen carefully to the sentences and repeat exactly what they hear (to the best of their ability). Children's responses were voice-recorded and subsequently transcribed for further analyses.

The transcribed responses from the children were scored for overall accuracy, grammaticality and correct use of the target structure. Overall accuracy was derived using a scale from 0–3 for each sentence. Responses that contained no deviation from the target sentence were awarded 3 points. Responses that contained one deviation from the target sentence were scored with 2 points and responses that contained 2–3 deviations received 1 point. Responses that contained more than 3 deviations from the target sentence were awarded 0 points. Thus, for overall accuracy the maximum score for the English SRT was 90 and for the Greek SRT 96. Note that for both languages, responses with scrambled word order (i.e., different word order from the target sentence, but still grammatical) were coded as one deviation per phrasal unit that did not occur in the target position. Similarly, errors that affected an entire noun phrase or prepositional phrase (i.e., number, case or gender errors) were counted as one deviation only. This was done in order to keep the scoring consistent across languages, since Greek has considerably more inflectional morphology than English. Thus, both *the child* instead of *the children* and *το παιδί* instead of *τα παιδιά* were counted as one deviation.

Because overall accuracy scores for the SRT are likely to be affected by the children's vocabulary and memory skills, responses were also scored for grammaticality and correct use of target structure in order to get a purer measure of the children's grammatical abilities. For the grammaticality score, each of the responses was judged for grammatical correctness, regardless of whether the sentence matched the target sentence and whether it was semantically anomalous. Consequently, the maximum score for grammaticality was 30 for the English SRT and 32 for the Greek SRT. Finally, the responses were scored with regard to the correct use of the target structure (structure scores). If the response contained a correct use of the target structure, it was scored with 1, regardless of whether the overall sentence was grammatical or complete. If the response did not show correct use of the target structure, 0 points were awarded. Children's responses were scored using a set of criteria for the various structures. For example, for English SVO sentences, the three sentence elements had to be in the right order and the child needed to use a verb phrase that included one or two auxiliaries, or a model verb and an auxiliary. For passives, a grammatical subject was required plus either a be-passive or get-passive construction, and for long passives a by-phrase had to be present, too. For object questions, the response had to contain a fronted wh-question word followed by subject-verb inversion. In sentences targeting sentential adjuncts, the adverb or the conjunction (i.e., if) had to be accompanied by a main and a subordinate clause which had to be correctly marked for tense. For object relative clauses, a relative clause had to be present modifying an object, although the relative pronoun could be dropped from the sentence. Turning to Greek, for negation, a score of 1 was awarded if the response contained the target negator at the right position in the sentence. If the target structure was an adverbial clause, the child had to produce the target adverb followed by a subordinate clause as well as a main clause carrying the correct tense. Points for coordination were awarded if the child produced the correct coordinator together with two main clauses. Sentences with relative clauses as the target structure were required to contain a relative pronoun and a subordinate clause that modified the target antecedent (i.e., subject vs. object relative clause). Items that targeted basic word order (SVO) had to contain a subject, a main verb and an object in the right positions in order to be scored as correct. For complement clauses, the child had to produce the correct complementizer together with a subordinate clause. Similarly, for Wh-complements, the response needed to contain a wh-word and a subordinate clause in order to be scored as correct in terms of target structure. Points for clitic doubling were given if the child produced a clitic at the right position in the sentence. Finally, items targeting clitic left dislocation needed to contain a fronted DP and a clitic at the right position in order to be awarded 1 point. The maximum score for correct use of the target structures was 30 for the English SRT and 32 for the Greek SRT. Table 11 summarizes the scoring scheme for the two SRTs.

Table 11. *Scoring scheme for overall accuracy, grammaticality and correct use of target structure for the SRT tasks with examples.*

Overall Accuracy		
3	no deviations from target	*The boy that the milkman helped has lost his way.*
2	1 deviation from target	*The boy that the milkman helped has lost* ***the*** *way.*
1	2-3 deviations from target	*The boy* ********* *the milkman helped* ***had*** *lost his way.*
0	>3 deviations from target	*The boy that is the milkman got lost.*
Grammaticality		
1	grammatical	*The boy that has the milk got lost.*
0	ungrammatical	*The boy that has the milkman helped has lost his way.*
Correct use of target structure		
1	correct structure	*The boy that the milkman helped got lost.*
0	incorrect structure	*The boy that helped the milkman has lost his way.*

Narrative skills

Children’s narrative skills were assessed using a story re-tell task. The original stories (i.e., the pictures) were taken from the Edmonton Narrative Norms Instrument (ENNI; Schneider, Dubé & Hayward, 2005). The ENNI consists of two parallel sets of black-and-white picture series with three levels of complexity each. The level 1 stories consisted of 5 pictures featuring two characters, the level 2 stories were made up of 8 pictures featuring three characters and the level 3 stories were 13 pictures in length with four characters. Set A features an elephant and a giraffe and set B has a bunny and a dog as protagonists. Because the ENNI material was only designed to be used in the telling mode, it does not include any model stories that could be used for a re-tell task. As a consequence, model stories for four of the picture series (A2, A3, B2 and B3) were developed in various languages including English and Greek by Andreou, Knopp, Bongartz and Tsimpli (2015) as part of a larger research project on bilingualism (BALED). The model stories were matched across languages (English vs. Greek) and sets (A2 vs. B2, A3 vs. B3) for syntactic complexity (i.e., verb diversity, number of coordinate and subordinate clauses), as well as narrative complexity in terms of story grammar (i.e., number of goals, attempts, outcomes and internal states). Finally, the model stories were recorded by native speakers of English and Greek respectively, and were aligned with the pictures in a PowerPoint presentation. The four model stories in English and Greek are attached in Appendix I together with the corresponding picture series.

To administer the task, the children were seated in front of a laptop computer and were given a set of headphones to prevent any noise disruption. They were told that they were going to hear a story accompanied by pictures and were instructed to listen to the story carefully as afterwards, they would have to re-tell the story to the experimenter who has not heard or seen it before. The first screen of the PowerPoint presentation showed three different envelopes (see Figure 6) that the child was told contained three different stories to choose from. In fact, the same story appeared regardless of which envelope they chose. This little deception was done to give the child the impression that the story selection was not controlled by the experimenter in order to encourage them to re-tell the story as detailed as possible since the experimenter would not know which story they had heard. As soon as the child picks an envelope, the first two pictures appear and the story starts. There were one or two pictures per screen and the slides proceeded automatically as soon as the corresponding part of the model story script ended. Figure 7 shows an example of a screen and the corresponding script the child heard.

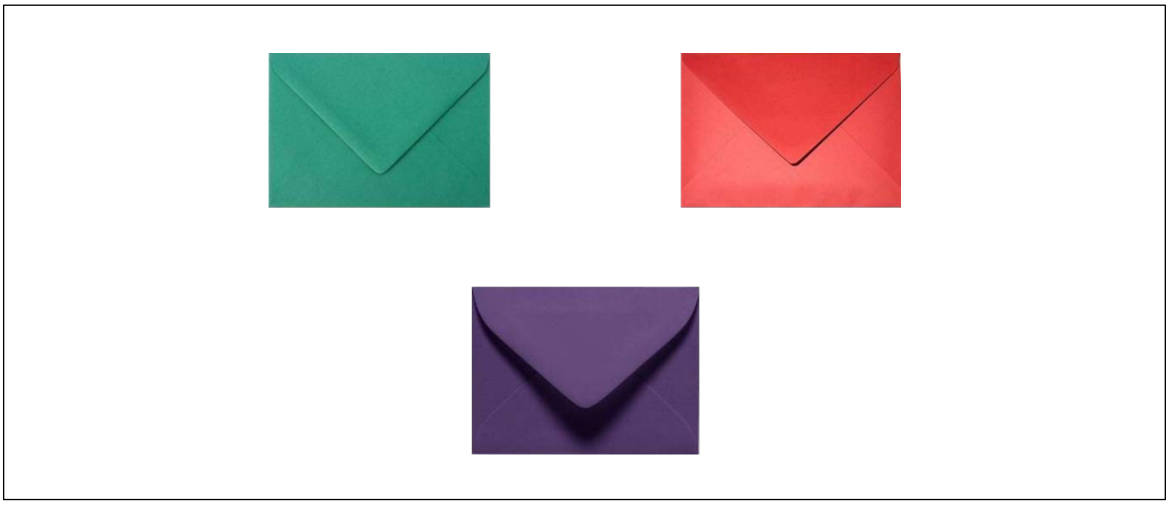
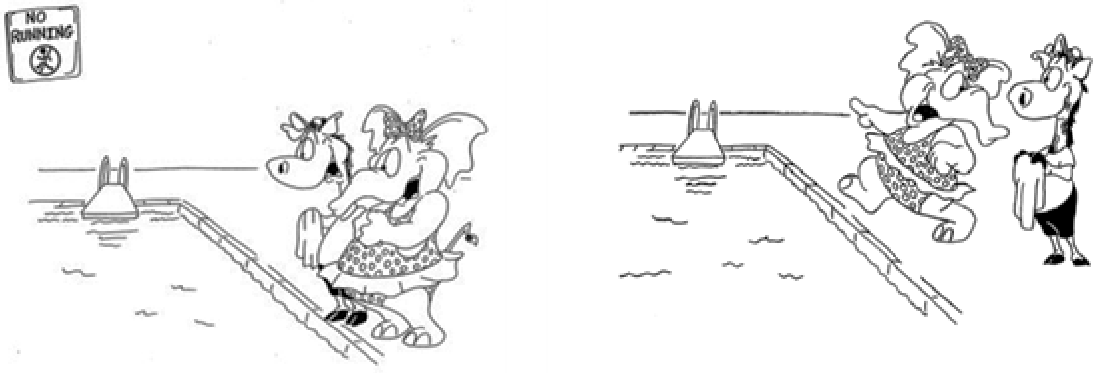


Figure 6. Starting screen for the story re-tell task with the three envelopes that children were told would contain different stories to choose from.



English: *One day a happy giraffe boy and a playful elephant girl went out to the nearby swimming-pool. Elephantina noticed a diving board from which they could dive as many times as they wanted. But neither of them saw the sign that said "NO RUNNING". Not wasting any time, Elephantina decided to start a competition by saying "Let's see who will be there first!".*

Greek: *Μια μέρα μία χαρούμενη καμηλοπάρδαλη αγοράκι, ο καμηλοπάρδαλης και μία παιχνιδιάρα ελεφαντίνα πήγαν βόλτα στην πισίνα της γειτονιάς τους. Η ελεφαντίνα αμέσως πρόσεξε μία σανίδα από την οποία μπορούσαν να κάνουν πολλές βουτιές. Κανείς τους όμως δεν είδε τη ταμπέλα που έγραφε "μην τρέχετε". Για να μη χάσουν χρόνο η ελεφαντίνα αποφάσισε να ξεκινήσει το παιχνίδι λέγοντας στον καμηλοπάρδαλη "Ας δούμε ποιος θα φτάσει πιο γρήγορα στη σανίδα! ".*

Figure 7. First two pictures from story A2 and corresponding scripts in English and Greek.

When the story had finished, the children were told to take off the headphones and were asked a series of comprehension questions (see next section on language comprehension). After that, they were shown all the pictures of the story arranged in a strip (see Figure 8). They were then asked to re-tell the story they had just heard over the headphones to the experimenter using the picture strip in front of them. Children’s stories were voice-recorded and subsequently transcribed for further analyses. The monolingual children were assessed on two stories of two different levels. In each monolingual group, half of the children did stories A2 and B3, while the other half was administered B2 and A3. The bilingual children heard all of the four stories, i.e., A2 and B3 in one language and B2 and A3 in the other with the two combinations being counterbalanced across languages. Within a language, the slightly easier level 2 story was always presented before the level 3 story.

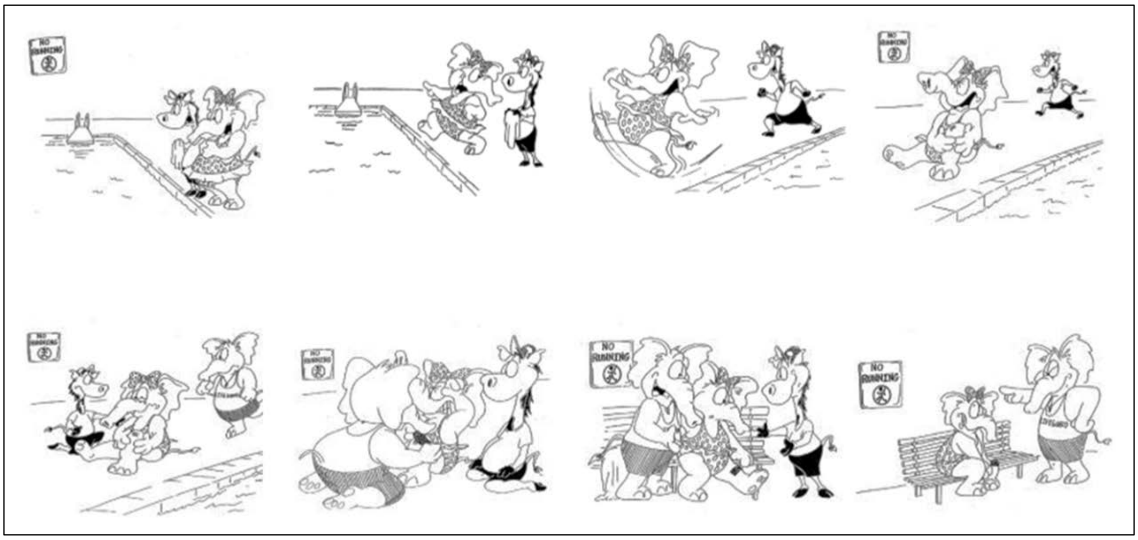


Figure 8. Picture strip given to the children to re-tell the story.

Narratives offer a wealth of information about language skills which are typically divided into two levels: microstructure measures and macrostructure measures. Measures of narrative abilities at the macrostructure level are mainly concerned with the content and structure of a story. Microstructure measures, on the other hand, typically refer to the quality of the narrative in terms of morphosyntax and vocabulary. The present study used four measures of narrative skills at the level of microstructure: i) length; ii) verb diversity; iii) syntactic complexity, and iv) grammaticality. First, the data from the level 2 and the level 3 stories in each language were combined to obtain a speech sample of sufficient length for the syntactic analyses (i.e., microstructure measures). The narrative samples were subjected to a clausal analysis in which all main clauses and subordinate clauses were identified. The subordinate clauses were further coded for complement clauses (e.g., *he tried to reach it; he said that it was too far away; the lifeguard asked what happened*), relative clauses (e.g., *an elephant who had been watching came over*), and adverbial clauses (e.g., *Elephantina watched while Giraffo was playing with his toy*). Instances of direct speech were treated as separate clauses and not as complements to the main verb of the 'introductory' sentence. Instances of coordination between subordinate clauses were counted as separate occurrences of subordination (e.g., *When she fished it out and put her hands on it, she gave it to the giraffe.* was counted as one main clause and two adverbial clauses). Like the other measures, verb diversity too was calculated over both stories in each language. Auxiliaries, modals and semi-modals (e.g., *should, can, could, might, need to, have to, etc.*) were included in the clausal analyses, but were not considered for the calculation of verb diversity. In some cases, children asked the experimenter to provide them with a particular word (i.e., translations from either language) or inserted words in the other language (typically English words inserted into the Greek stories) in order to maintain the flow of the story. Such instances were transcribed, but were not included for the calculation of the microstructure measures. However, words that the children produced in the non-target language and words that were provided by the experimenter were counted as grammatical errors.

Narrative length was calculated by adding the total number of main and subordinate clauses in the narrative sample of each child. For verb diversity, the number of different main verbs produced was divided by the total number of main verbs in the narrative sample (type-token ration)[20]. Syntactic complexity of the produced narratives was indexed by the ratio between subordinate and main clauses. Finally, a measure of grammaticality was derived by dividing the number of grammatical errors in the narrative sample by the length of the narrative (i.e., total number of main and subordinate clauses). The four microstructure measures and their calculations are summarized in Table 12.

Table 12. *Summary of microstructure measures.*

Measure	**Description**
Length	number of clauses (main + subordinate)
Verb diversity	type/token ratio of verbs used
Syntactic complexity	ratio between subordinate clauses and main clauses
Grammaticality	ratio between number of grammatical errors (morphosyntactic, not lexical) and number of clauses

Language Comprehension

In addition to the narrative re-tell task, children also had to answer comprehension questions about the stories they heard. The answers to those questions were used as a measure of language comprehension skills. The comprehension questions that were used in this project were a subset of the questions provided by the ENNI (Schneider et al., 2005). After hearing the first story (A2/B2) children were asked 10 questions probing either factual information (n=6) or mental states of the characters (n=4), while the second story (A3/B3) was followed by 14 questions whereby 8 were about factual information and 6 about mental states of the characters. The questions across sets were exactly the same only that they referred to different characters (i.e., those featured in the particular story). Table 13 gives an overview of the comprehension questions with some examples. The full list of questions for each story can be found in Appendix J.

[20] Note that the type-token ratio measure of lexical diversity is confounded with length in that the ratio drops with increasing narrative length (see, Treffers-Daller, 2013 and Treffers-Daller & Korybski, 2016, for detailed discussion of the issue).

Table 13. *Overview of comprehension questions.*

	A2/B2	A3/B3
Factual information	n=6	n=8
Examples	• *Who is the story about?* • *Where are the animals?* • *What did the elephant girl/rabbit do then?* • *Why did the friends feel like that?*	
Mental state of characters	n=4	n=6
Examples	• *How did the elephant girl/rabbit feel here?* • *What did the lifeguard/doctor think here?* • *How did the two friends feel here?*	

Before the children heard the stories, they were told that they had to listen carefully as they would have to answer a few questions about the story in addition to re-telling it to the experimenter. Once the story had finished, children were instructed to take off the headphones and were shown a booklet containing the pictures of the story. Apart from the first two questions which were the same across all four stories (*"Who is the story about?"* and *"Where are the animals?"*), each question referred to a particular picture of the story. Therefore, the experimenter turned to the appropriate page of the booklet and pointed to the picture before asking the question. Children's responses were voice-recorded for subsequent transcription and analyses. The comprehension questions were used to measure children's understanding of the story and the question itself rather than their ability to produce a grammatical answer. Consequently, responses that were provided in the non-target language were acceptable. Moreover, some of the questions referred to information that was directly provided in the story script that they heard, while some required the children to make inferences. Thus, responses were scored as correct if they constituted a reasonable answer to the question and if they were consistent with the information from the story. However, responses that referred to the wrong sequence or episode than the one depicted by the picture that accompanied the question were scored as incorrect.

2.3.3 Executive function measures

Executive function is an umbrella term that refers to a set of mental processes that are necessary for the cognitive control of behaviour. The executive control system comprises several components that show a fair amount of interdependence, but are nevertheless separable (Miyake & Friedman, 2012; Miyake et al., 2000). Consequently, children were assessed on multiple measures of executive function skills that tap different components, such as verbal and non-verbal working memory, updating, switching and inhibition. The present section describes the various tasks and the measures that were derived from them.

Verbal working memory

The digit backwards span task from the Automated Working Memory Assessment Battery (AWMA; Alloway, 2007) was used to measure children's verbal working memory skills. The task requires participants to listen to a series of one-digit numbers, with the lists spanning from two to seven numbers, and repeat them in backwards order. There are a maximum of 6 trials for each digit span and testing is discontinued if a child errs on three consecutive trials. In addition, if the child gives four correct answers for a given span, any remaining trials of that same span are assumed to be correct and the child moves on to the next span. The final score is the total number of correct trials with a maximum of 36. The full list of trials is attached in Appendix K.

The experimenter explained the task to the child and read out the digits with a pause of one second between digits. To familiarize the children with the task, four practice trials were administered, two with two digits and two with three digits. During the practice trials, children were given feedback to ensure that they understood the task. After the practice trials, the experimenter proceeded with the experimental items during which no feedback was provided. The experimenter simply read out the trials and informed the child when they got to the next span (e.g., *"Let's try with three numbers now.")*. Each trial was read out only once (i.e., the experimenter was not allowed to repeat a given trial upon the child's request). Children's answers were recorded on a score sheet (see Appendix K). There was an English version and a Greek version of the task whereby the Greek one was simply a translation from English, i.e., the exact same trials and digits were used. The bilingual children did the task twice, once in English and once in Greek with the sessions being at least one week apart. This was done to see to what extent task performance was influenced by language proficiency.

Non-verbal working memory

Non-verbal working memory skills were assessed with the Mr. X task taken from the AWMA (Alloway, 2007). The task requires children to simultaneously process and store visuospatial information of rotating figures. The task design was similar to the backwards digits task in that the number of locations the child had to remember increased across trials. The number of locations to be recalled spanned from one to seven and there were again 6 trials per span amounting to a total of 42 trials. As with the digits backwards task, testing was discontinued if the child failed on three consecutive trials and four correct answers on a given span meant that any remaining trials of that same span were assumed to be correct and the experimenter proceeded with the first trial of the next span. The final score was the total number of correct trials out of a maximum of 42.

The original task from the AWMA (Alloway, 2007) was converted into a PowerPoint presentation. Children sat in front of a computer laptop and listened to the experimenter's instructions. The first slide shows two Mr. X's and children are asked to identify whether the

Mr. X with the blue hat (on the right) is holding the ball in the same hand as the Mr. X with the yellow hat (on the left). The Mr. X with the yellow hat is always in the same upright position functioning as a reference point, while the Mr. X with the blue hat may be rotated to six different positions (see Figure 9). At the same time, children are told to try to remember the location of the ball the Mr. X with the blue hat is holding. The next slide shows six points indicating the six possible positions where the Mr. X might be holding the ball and children are asked to point to the position where the Mr. X with the blue hat previously held the ball (see Figure 10).

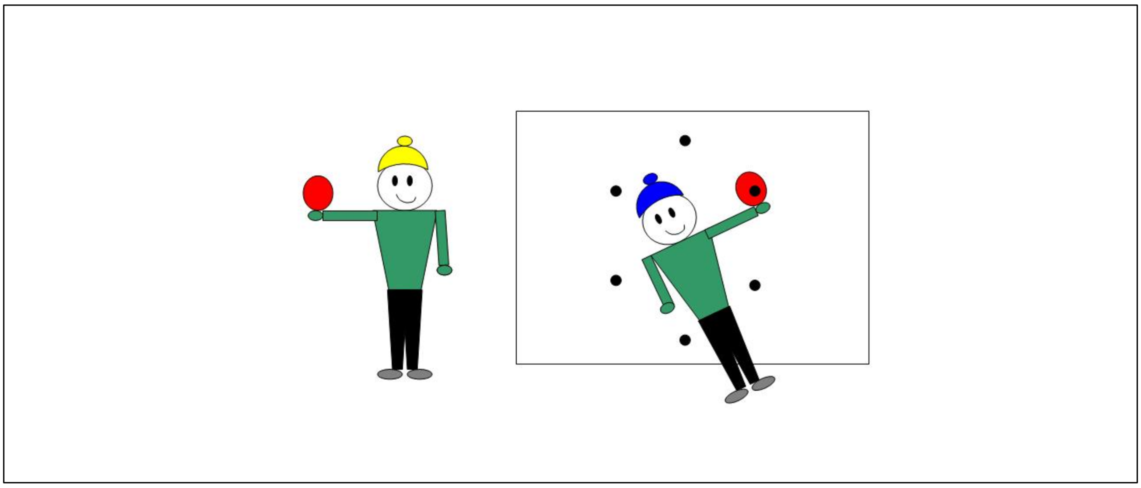


Figure 9. Screen showing two Mr. X's where children had to identify whether the Mr. X with the blue hat is holding the ball in the same hand as the Mr. X with the yellow hat. Children also had to remember the position of the ball which the Mr. X with the blue hat is holding. The six dots indicate the possible locations where the Mr. X with the blue hat could be rotated to. However, there were no dots on these slides in the experimental trials.

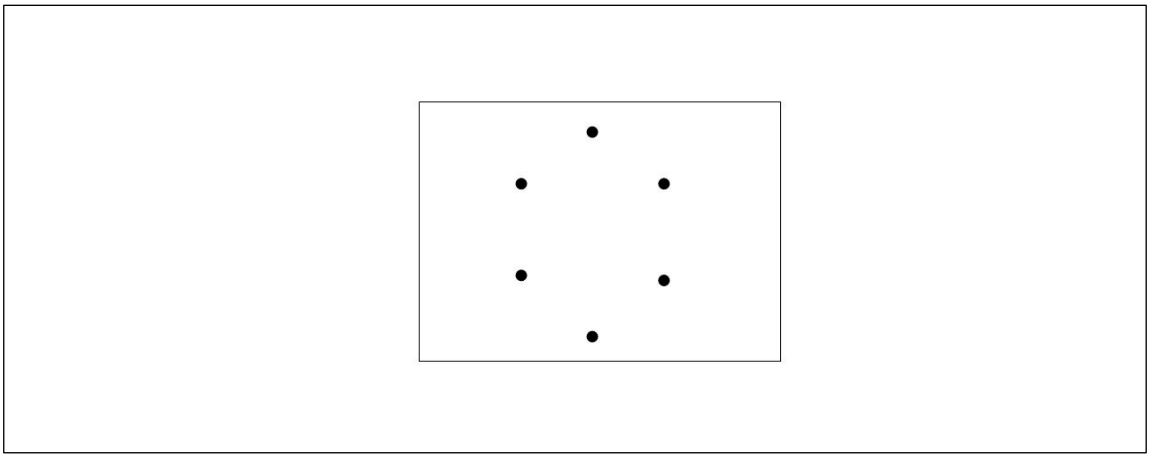


Figure 10. Screen presented at the end of each trial showing the six possible positions of the balls where children had to point to the locations of the balls on previous screens.

For the span 1 trials, children were presented with one pair of Mr. X's and thus, had to recall one location of the ball. In span 2 trials, the children saw two subsequent screens of pairs of Mr. X's and they had to say whether the Mr. X with the blue hat is holding the ball in the same hand as the other Mr. X for each of the two screens. At the end of span 2 trials, the children were again shown the screen with the dots and were asked to point to the location of the ball in each previously shown pair in sequence. Each subsequent span added another pair of Mr. X's and thus, an additional location the child had to recall at the end of the trial, up to a maximum of seven (i.e., span 7). Both the slides with the Mr. X's and the slides with the dots stayed on the screen until the child gave a response. At the beginning of the task, the child was taken through the procedure step by step and four practice trials were administered (two span 1 and span 2 trials each) during which feedback was provided. After ensuring that the child understood the task, the experimenter proceeded with the experimental trials and no more feedback was given. Children's responses were recorded on a score sheet. A trial was only scored as correct if the child correctly identified whether the Mr. X with the blue was holding the ball in the same hand as the other one AND if they correctly recalled the location of all the previously seen Mr. X's in the right sequence at the end of the trial. Otherwise, the trial was awarded a 0 score.

Given the non-verbal nature of the task, there was no need for the bilingual children to do the task in both languages. Thus, unlike the backwards digits task, the Mr. X task was only administered once for the bilingual children and the instructions were given in the language they felt more comfortable with.

2-back task (updating)

The 2-back (or *n*-back tasks more generally) is a commonly used measure to tap into the updating and monitoring components of executive functions. Subjects are presented with a sequence of stimuli and the task is to monitor the incoming stimuli and indicate when the current stimulus matches the one they saw *n* steps earlier in the sequence. The cognitive load (i.e., *n*) can be manipulated to increase or decrease task demands. The version used in this project used digits as stimuli and the cognitive load was 2, hence the name "2-back" task. The experiment was conducted on a laptop computer using E-Prime software (Schneider, Eschmann & Zuccolotto, 2002). The stimuli consisted of four digits (2, 5, 7 and 8) that were presented in a pseudo-random sequence of 60 trials. Each digit stayed on the screen for 500ms and was followed by a blank screen for 2500ms. Children were seated in front of a computer laptop and were instructed to monitor the digits appearing on the screen and to press the 'J' key as quickly as possible whenever the current digit on the screen matched the one that appeared two steps back. The 'J' key was marked with a coloured sticker on the keyboard and children were told to keep their index finger on the 'J' key throughout the experiment to prevent them from pressing a wrong key. They were also told that if the digit they currently saw on the screen was not the same as the one they saw two trials before or, if they were not sure, they should not press anything and just wait for the next digit to appear. For example, in the sequence 8-**2**-5-**2** children were expected to press the 'J' key on the last digit as it is identical to the one that appeared two steps back (see Figure 11, for further illustration). To familiarize the children with the task, a practice block was administered consisting of 20 trials (i.e., a sequence of 20 digits), 6 of which were updating trials and thus, required pressing the 'J' key and 14 no updating trials that did not require any response. After ensuring that the child understood the task, the experimenter proceeded with the experimental block that consisted of 20 updating trials (thus, requiring pressing the 'J' key) and 40 no updating trials resulting in 60 trials in total. Both accuracy and reaction times (RTs) were recorded. However, RTs are typically used to compare different conditions within the task such as 2-back conditions and 3-back conditions (e.g., Miller, Price, Okun, Montijo & Bowers, 2009). The 2-back task used in the present study did not include any manipulation of cognitive load, hence, only accuracy was analysed. As with the Mr. X task, the 2-back task was administered once with the bilingual children and instructions were provided in the language the children felt more comfortable with.

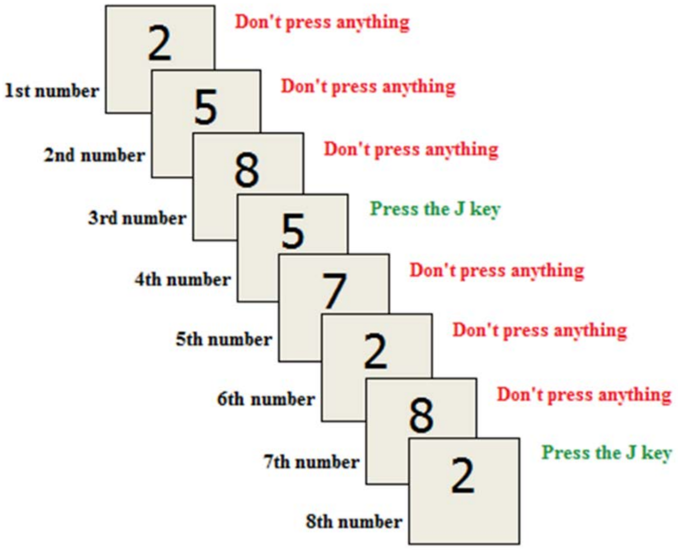


Figure 11. Screen that was used to explain the 2-back task to the children. They were told that a series of digits would appear on the screen one-by-one and that they had to monitor the sequence and press the 'J' key as quickly as possible whenever the current digit was the same as the one that appeared two before. In this example sequence, the 4th and the 8th digit would require pressing the 'J' key.

Overall task performance was calculated in two ways. The first one was a composite score whereby the percentage of false alarms (i.e., incorrect button presses on no updating trials) was subtracted from the percentage of correct hits (i.e., correct button presses on updating trials). The composite score was preferred over simple overall accuracy scores because it is possible that a child is overly conservative and refrains from pressing the 'J' key altogether in which case the raw accuracy would still be fairly high (around 66%) as the 40 no updating trials which constitute two thirds of the total number of trials would all be counted as correct. Another way to overcome this caveat is to derive *A*'scores which is a commonly used measure of discriminability for Yes/No tasks in signal detection theory (Stanislaw & Todorov, 1999). To calculate *A*' scores, participants' hit rates (H) and false-alarm rates (F) are entered into a formula[21] (see Figure 12). For ease of interpretation, the values were multiplied by 100 so that the resulting *A*' scores range between 0 and 100, where 100 indicates perfect discriminability and 50 indicates chance performance.

$$A = \begin{cases} \frac{3}{4} + \frac{H-F}{4} - F(1-H) & \text{if} \quad F \le 0.5 \le H\,; \\ \frac{3}{4} + \frac{H-F}{4} - \frac{F}{4H} & \text{if} \quad F \le H < 0.5\,; \\ \frac{3}{4} + \frac{H-F}{4} - \frac{1-H}{4(1-F)} & \text{if} \quad 0.5 < F \le H\,. \end{cases}$$

Figure 12. Formula used to calculate the A' scores for the 2-back task. Adapted from "A note of ROC analysis and non-parametric estimate of sensitivity," by J. Zhang and S. T. Müller, 2005, *Psychometrika*, 70, 203-212. Copyright 2005 by the Psychometric Society.

Global-Local task (switching and inhibition)

The Global-Local task (GLT) is another measure of executive function abilities that was used to tap into two other components of executive function skills, namely inhibitory control and switching (i.e., attention shifting). In this task, a trial consists of a picture showing a large shape (global level) that is made up of lots of smaller shapes (local level). There are four shapes in the task: circles, crosses, triangles and squares. One fourth of the trials were congruent (same shape on both levels) and the remaining 75% were incongruent (different shape across the two levels, e.g., a large circle made up of small triangles). Figure 13 shows an example of a congruent and an incongruent trial. The task was divided into three blocks, two single blocks and one mixed block, that consisted of 64 trials each (16 congruent and 48 incongruent). In the single blocks, children had to respond to either the local or global level, while in the mixed block they had to

[21] The *A*' scores were calculated with the aid of a spread sheet made available by Zhang and Mueller (2005) which can be found at https://sites.google.com/a/mtu.edu/whynotaprime/.

alternate between paying attention to the global and local levels. In the mixed block, a cue was provided on top of the figure to help children remember which level they need to pay attention to (i.e., global or local). In the English version of the task, the cue for paying attention to the large shape (i.e., global trials) was the capital letter "**L**" printed in blue and the cue for focusing on the small shapes was the small letter "**s**" in red. In the Greek version of the task, the cues were the letters "**μεγ**" printed in blue (standing for *μεγάλα σχήματα* "large shapes") for global trials and the letters "**μικ**" printed in red for local trials (standing for *μικρά σχήματα* "small shapes"). Figure 14 shows example screens from the mixed block with the cues for the English and Greek version. The order of presentation of the two single blocks was counterbalanced across participants so that half the children in each group were presented the Global block first (and the mixed block started with a global trial) and the other half were administered the Local block first (and the mixed block started with a local trial).

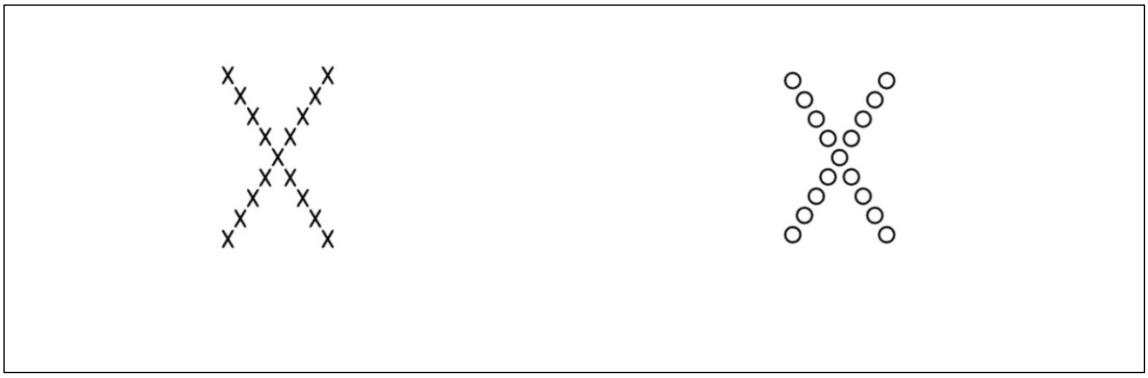


Figure 13. Example of a congruent trial (same shape on global and local level, see figure on the left) and an incongruent trial (cross on the global level and circles on the local level, see figure on the right) in the Global-Local task.

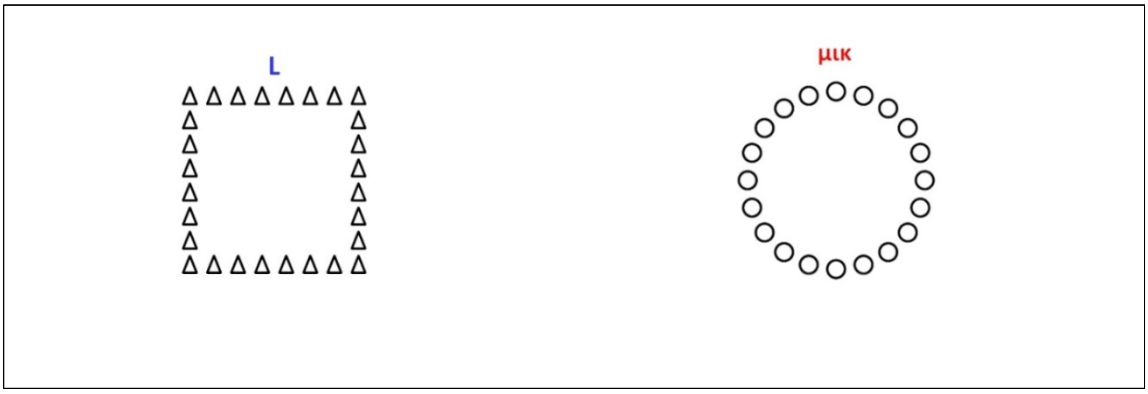


Figure 14. Examples from the mixed blocked showing the cues that were used to remind the children whether they needed to focus on the large shape (global trials) or small shapes (local trials). **L** = large shapes; **s** = small shapes, **μεγ** = μεγάλα σχήματα "large shape **μικ** = μικρά σχήματα "small shapes".

The task was administered on a computer laptop using E-Prime software (Schneider et al., 2002). Children were seated in front of a laptop computer and the experimenter went through the instructions that appeared on the screen. In the global block, they were told to only focus on the large shape they see and to press one of four keys on the keyboard depending on how many lines are needed to draw a given shape. Thus, they were instructed to press “1” on the keyboard if the large shape was a circle, “2” if it was a cross, “3” for a triangle and “4” for a square. The instructions for the local block were exactly the same except that children were told that in this round they should only pay attention to the small shapes they see and again press the number from 1–4 that shows how many lines that shape is made out of. In the mixed block, they were told that they would have to switch between focusing on the large and small shapes and were explained the respective cues. The response keys were arranged so that they were in the middle of the keyboard and marked with stickers with the numbers 1–4 written on them (“1” on the “D” key, “2” on the “F” key, “3” on the “J” key and “4” on the “K” key). The stimuli remained on the screen until the children pressed a key. Children were further instructed to do the task quickly but at the same time carefully. The two single blocks were preceded by six practice trials during which feedback was provided and the more complex mixed block had ten practice trials. There was a short break between each block. Both accuracy and response times were recorded. Following standard procedure, the analysis of the reaction time data discarded incorrect trials and trials with RTs below 250ms as these have most likely been initiated before the stimulus. Being a non-verbal task, the GLT was administered to the bilingual children once with the instructions provided in the language of their choice.

The two measures of interest derived from the GLT were the congruency effect and the (global) switching cost. The congruency effect is a measure of inhibition (or selective attention) and indicates to what extent the participant is distracted or slowed down by conflicting information in incongruent trials. The effect is typically calculated by subtracting the mean RT from congruent trials from the mean RT of incongruent trials. However, inspection of the data showed a great amount of variation in RTs both within and between subjects. For this reason, median RTs were used instead of mean RTs in order to reduce the effect of outliers. The congruency effect was thus calculated as the difference in median RTs between the congruent and incongruent trials of the two single blocks. The second measure of interest, the switching cost, is a measure of attention shift or switching and is also computed on the basis of RTs. Different types of switching costs have been used in the literature depending on the task design. In the present study, the switching cost was calculated by comparing performance on the mixed block with performance on the single blocks which is commonly described as *global* switching cost (or mixing cost). In contrast, *local* switching costs are computed by comparing switch and non-switch trials within the same block. In the GLT used in the current study, the mixed block contained exclusively switch trials (i.e., every trial required switching attention from one level to another level) rather than a combination of switch and non-switch trials (i.e., trials that do not require switching attention to a different level from the previous one). Thus, the switching cost was calculated by subtracting the median RT on incongruent trials in the single blocks from the median RT on incongruent trials in the mixed block[22]. Table 14 summarises the two measures of executive function skills and the way they were calculated.

Table 14. *Summary of the two EF measures with their descriptions and calculations.*

EF measure	**Description**	**Calculation**
Congruency effect	ability to inhibit conflicting information	median RT for incongruent trials in single blocks – median RT for congruent trials in single blocks
Switching cost	ability to continuously switch attention between two levels of information	median RT for incongruent trials in single blocks – median RT for incongruent trials in mixed block

Letter fluency task

The letter fluency task is a widely used test that is often referred to as a hybrid task as it taps both verbal ability (i.e., vocabulary and lexical retrieval) and executive function skills (Shao, Janse, Visser & Meyer, 2014). In this test, participants are given 1 minute to produce as many different words as they can think of starting with a particular letter. Thus, participants are required to search their mental lexicon and quickly retrieve words that start with the target letter. However, there are a number of constraints on the words that are acceptable (e.g., proper nouns and related words are not acceptable). Consequently, the task also taps into executive function abilities as participants must keep the instructions and previously given responses in working memory to avoid producing unacceptable responses and repetition which, in turn, implicates the inhibition component of the EF system. Despite the verbal component of the test, the letter fluency task was grouped together with the executive function measures.

Children sat next to the experimenter and were told that in this task they had to produce as many different words as possible that start with a particular letter. The test consists of three trials, consequently the task is repeated three times with a different letter in each trial. The most commonly used version of the test in English uses the letters *F*, *A* and *S* (Spreen & Strauss, 1998) which are also the letters used in this study. The Greek version of the task included the letters *Χ* (Chi), *Σ* (Sigma) and *Α* (Alpha) which were equivalent to the English letters *FAS* in terms of the ratio of words starting with these letters relative to the total number of words in a

[22] Note that typically the global switching cost is calculated by comparing performance on non-switch trials across single and mixed blocks (Hernández et al., 2013; Prior & MacWhinney, 2010). However, given the current design, there were no non-switch trials in the mixed block, so the switching cost was calculated by comparing non-switch trials in the single blocks with switch trials in the mixed block.

dictionary of that language (Kosmidis, Vlahou, Panagiotaki & Kiosseoglou, 2004). Children were instructed to avoid responses that were names of people or places, and to try to say different words. So for example if they say a group of words like *run, runner, running*, it would count as one correct response since they are (closely) related words. Each trial started as soon as the target letter was announced upon which the experimenter started the timer that was set for 1 minute. Children's responses were recorded on an answer sheet and subsequently entered into a spread sheet.

Responses that contained proper nouns (i.e., names of people or places) were excluded from analyses, as were repetitions and responses that were morphologically related to previous responses. More specifically, groups of words from the same inflectional paradigm such as *swim, swam, swimming* or *snake, snakes* were counted as one correct answer each. Similarly, groups of words that were closely related by means of derivational morphology such as *admire-admiration-admirable* or *actor-actress* were scored as one correct response respectively. However, repetitions that occurred as part of a compound (e.g. *sun, sunflower, sunglasses*) were acceptable as they were deemed to be sufficiently different in meaning to constitute separate lexical entries in the (child's) lexicon. Other unacceptable responses included words that started with a different letter than the target letter (e.g., *owl* for the letter *A* or *cinema* for the letter *S*) since the instruction explicitly says words starting with the *letter* and not the *sound*. The final score was the sum of correct responses across the three trials (i.e., letters). Due to the verbal component, the bilingual children did the task twice, once in English and once in Greek with the sessions being at least one week apart.

2.3.4 Literacy measures

Literacy was assessed in terms of children's reading skills in English and Greek. The tasks included rapid serial naming of digits, single word reading, reading comprehension and a lexical decision task with written stimuli. The current section describes the various tasks in more detail.

Rapid automatized naming (RAN)

To measure rapid serial naming we used the rapid digit naming subtest from the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen & Rashotte, 1999). The task requires participants to rapidly access and retrieve the phonological representations of highly familiar stimuli (digits, letters, colours or common objects) in sequence. The subtest with digits was chosen for the present study because alphanumeric RAN (digits and letters) have been shown to be better predictors of reading performance than rapid naming of colours or objects (Manis et al., 2000), and because digits are less confounded than letters by differences in length and frequency across languages. There is an EF component to this task in that different processes are being carried out simultaneously. On seeing the first stimulus, the participant has to retrieve the phonological form from memory and plan the oral production of the stimulus.

While still orally producing the stimulus, the participant already retrieves the phonological form of the next one and so on. Thus, RAN requires the orchestrating of several processes simultaneously, namely lexical retrieval, memory and oral production.

In this task, six digits (2, 3, 4, 5, 7, 8) are repeated six times and presented across four lines of nine digits each (see Appendix L). Children are asked to read out the 36 numbers on the card one-by-one as fast as possible, starting from the top left corner and going from left to right until they come to the end at the bottom right corner. The procedure is repeated with a second card containing the same numbers, but in reverse order. The total naming time is calculated by summing the time (in seconds) it took the child to name the digits on the two cards. The bilingual children did the RAN twice, once in English and once in Greek using the same cards, but with at least one week between the sessions.

Lexical Decision Task (LDT)

Lexical decision tasks are commonly used as measures of word recognition and lexical access. In the written mode, a letter string appears in the middle of the screen and participants have to decide whether it constitutes a real word or not, and press a corresponding button. Thus, in addition to word recognition and lexical access, visual lexical decision tasks also tap into decoding and orthographic processing skills.

English

The English version of the lexical decision task consisted of 45 real words and 45 pseudowords. The real words were taken from the Children's Printed Words Database (CPWD; Masterson, Stuart, Dixon & Lovejoy, 2003) which reflects the vocabulary in reading materials for children aged 5–9 years in the UK. The database consists of 1011 books, and contains 12,193 different word types and 995,927 word tokens. The real word items were selected to represent three different levels of frequency based on ranges proposed by Kučera and Francis (1967) which have been adopted by many researchers (e.g., Burgess & Livesay, 1998; Gardner, Rothkopf, Lapan & Lafferty, 1987): 15 words of high frequency, 15 words of mid frequency and 15 words of low frequency. The pseudowords were created with the Wuggy which is a multilingual pseudoword generator (Keuleers & Brysbaert, 2010). The 45 pseudowords were selected to fall within three different categories depending on their neighbourhood density, i.e., the number of real words that can be derived by substituting any one letter of a given pseudoword. Thus, 15 items had a dense neighbourhood, 15 items had a sparse neighbourhood and 15 items had no orthographic neighbours (no neighbourhood). The six conditions of the LDT are summarized in Table 15. All 90 items consisted of either one or two syllables and ranged in length between 4–7 letters with the number of syllables and letters balanced across conditions. The full list of items with their characteristics can be found in Appendix M.

Table 15. *Summary of the six conditions of the English LDT.*

REAL WORDS	Occurrences per million	**PSEUDOWORDS**	Orthographic neighbours (N)
High frequency	>100	Dense neighbourhood	>5
Mid frequency	30-70	Sparse neighbourhood	1-2
Low frequency	<10	No neighbourhood	--

The task was administered on a laptop computer using E-Prime software (Schneider et al., 2002). Children were told that they were going to see some letter strings in the middle of the screen, some of which were existing words in English and some were made-up by the experimenter. For each letter string, they had to decide whether it constitutes a real word in English or not, and press one of two buttons on the keyboard. If it was a real word, they were instructed to press the green button which was marked on the keyboard with a green sticker on top of the “0” key. If it was not a real word, they had to press the red button which was marked with a red sticker placed on the “1” key. They were told to respond as quickly and as accurately as possible. The items were presented in random order and each letter string remained on the screen until the child gave a response. To familiarize the children with the task, the 90 experimental trials were preceded by five practice trials during which feedback was provided. Both accuracy and RTs were recorded. For the analysis of the reaction time data incorrect trials were discarded as were trials with RTs below 250ms since these are most likely anticipatory.

Greek

The LDT in Greek was taken from Andreou (2015) and consisted of 140 items, 60 real words, 60 pseudowords and an additional set of 20 illegal non-words (i.e., non-words that violate the phonotactic rules of Greek). The real words varied in frequency, 20 words of high frequency, 20 words of mid frequency and 20 words of low frequency whereby the frequency counts were derived from Greek primary school textbooks used in Years 5 and 6. In each frequency condition (high, mid, low) 10 words were feminine and 10 words were masculine. The pseudowords were formed by changing either the first or second letter of an existing word with half of the pseudoword items displaying a typically feminine inflectional ending and the other half a typically masculine ending[23]. The resulting pseudowords varied in the frequency of the initial consonant clusters with 20 pseudoword items containing consonant clusters of high frequency, 20 items with consonant clusters of mid frequency and 20 items with consonant clusters of low frequency. The frequencies of the consonant clusters were based on the ISLP

[23] Note that in Greek grammatical gender (masculine, feminine and neuter) is marked overtly on all nominal endings. Although nominal endings in Greek are not entirely unambiguous with regard to gender, most endings have a strong predictive value for only one of the three genders (see Mastropavlou & Tsimpli, 2011; Varlokosta, 2011), and can therefore be described as ‘typically masculine or feminine’.

PsychoLinguistic Resource (Protopapas, Tzakosta, Chalamandaris & Tsiakoulis, 2012). The illegal non-words were formed by taking real words with initial consonant clusters and replacing either the first or second consonant with another, so that the resulting consonant cluster violated the phonotactic rules of Greek (i.e., they were unpronounceable). All 140 items were either two or three syllables in length (balanced across conditions). The full list of items and their characteristics can be found in Appendix N. Like the English version, the Greek version was administered on a computer laptop using E-Prime software (Schneider et al., 2002). The administration procedure and the instructions were the same as in the English version of the task (see above). Both accuracy and RTs were recorded.

Overall task performance on the LDT in English and Greek was calculated in two ways. Overall accuracy was calculated in terms of the total number of correct responses for both words and pseudowords (90 for English and 120 for Greek, excluding the 20 illegal non-words) converted into percentages. In addition to overall accuracy, *A'* scores were derived on the basis of hit and false alarm rates since the task design of the LDT is equivalent to a Yes/No task. Thus, correct responses to real words were coded as hits and incorrect responses to pseudowords were considered false alarms. A hit rate (H) and false alarm rate (F) was then calculated for each participant and the two rates were subsequently entered into a formula to derive the *A'* scores (see description of the 2-back task in 2.4.3 above for further details). Moreover, the effect of lexicality on children's performance was calculated by subtracting the median RT for real words from the median RT for pseudowords[24]. Thus, the lexicality effect reflects the extent to which children were slowed down in their responses to pseudoword stimuli using their RT to real words as a baseline. The 20 illegal items that were included in the Greek LDT were not considered in the above calculations. Instead performance on the illegal non-words was used as an exclusion criterion in that children who scored below 40% on these words were removed from the analyses of the Greek LDT.

English Decoding Task

Word reading skills in English (henceforth decoding) were assessed with the Single Word Reading Test (SWRT 6–16; Foster, 2007) which is included in the York Assessment of Reading for Comprehension for primary school children (YARC Primary; Snowling et al., 2009). The SWRT is standardized for children between 5–12 years old and consists of 60 real words of increasing difficulty which children are asked to read out loud (see Appendix O, for full list of items). The SWRT is not timed and thus measures only reading accuracy, not reading speed. The 60 items are presented on one page and are organized in sets of ten items. Children were instructed to read out the words on the page to the experimenter. If there was a word that they

[24] Median RTs were used rather than mean RTs because of the overall high latencies and the large variation.

were unfamiliar with they were encouraged to try to sound it out, but they also had the possibility to skip unknown or difficult words. No feedback was provided and testing stopped if the child appeared to reach ceiling, however, they were still given the opportunity to carefully consider the remaining words on the page. Children's responses were recorded on a score sheet and the final score was the total number of correctly read items out of 60. This raw score could then be converted into a standard score with a mean of 100 and a *SD* of 15.

Greek Decoding Task

Decoding skills in Greek were assessed with two subtests of the Test Alpha (Τεστ Ανάγνωσης "Reading Test") (TEST-A; Panteliadou & Antoniou, 2007). The TEST-A is a standardized assessment tool that provides measures for four component skills of reading: i) decoding accuracy, ii) morphological and syntactic awareness, iii) reading fluency, and iv) reading comprehension. The two subtests that were used to index decoding accuracy were word reading (53 items) and pseudoword reading (24 items). The full list of items of the two subtests can be found in Appendix P.

The pseudowords reading test was administered first. All of the pseudowords conformed to the phonotactic rules of Greek, i.e., only permissible letter combinations were used. The 24 items were organized in columns of increasing difficulty and presented on two cards. Children were asked to read out the words on the cards one-by-one and were reminded to pay attention to the stress accents[25]. No feedback was provided and children were encouraged to try and read all the pseudowords on the cards. The test was discontinued if children failed to correctly read out five consecutive items. The pseudoword reading subtest was followed by the single word reading test. The procedure and instructions were the same as in the pseudoword reading test. Items were again arranged in columns and children were asked to try and read out all the words on the three cards. Testing was stopped if children erred on five consecutive items. The final score was the total number of correctly read items out of 24 (pseudowords) and 53 (real words). The scores were kept separate and not combined into a composite score to facilitate comparison with the decoding measure in English given that the SWRT only includes real words. Although the TEST-A provides standardized norms for children from 8;9 to 14;9 years of age, standard scores could not be computed for the decoding component as the norms are for a composite score that includes a third task which was not administered for the present project.

English Reading Comprehension

Reading comprehension in English was assessed with the York Assessment for Reading Comprehension: Passage Reading Primary (YARC Primary; Snowling et al., 2009) which is a

[25] Modern Greek uses the diacritic mark (‘) to indicate stress, e.g., *τόνος* "stress".

standardized test suitable for use with primary school children (aged 5–11). The test requires children to read two passages (one fiction and one non-fiction) and to answer a series of comprehension questions that tap both literal and inferential comprehension skills. In addition to comprehension, the YARC passage reading also provides measures of reading accuracy and fluency, although only comprehension was assessed in the present project. The test comprises two parallel sets of passages (Form A and Form B) that are presented in a booklet. Only Form A was used in the present project. Each form contains seven passages that are graded in difficulty such that the Level 1 passage is aimed at children in Year 1, the Level 2 passage is aimed at children in Year 2 and so forth through to Level 6. The Level 1 passage is preceded by the Beginner passage aimed at children in reception. Each passage is accompanied by eight comprehension questions. Children read two passages (at adjacent levels) with the passages alternating between fiction and non-fiction so that each child read one passage of each type[26] (see Table 16, for an overview of the various topics of the passages). For the majority of children, the starting passage was determined on the basis of their Year group at primary school. However, for some of the children (especially bilinguals with relatively little exposure to English), the starting passage was below the expected level. In these cases, the level of difficulty of the first passage was chosen on the basis of their performance on the SWRT (the YARC provides a guide to choosing the starting passage level depending on SWRT raw scores).

Once the starting level has been chosen, children are asked to read out the passage to the experimenter. They are further instructed to read the passage carefully as, at the end of the passage, they would be asked some questions about the content. While children were reading the passage, the experimenter was allowed to correct them if they made reading errors to help maintain comprehension. However, if a child made too many reading errors (>15 at the Beginner Level, Level 1 and Level 2; >20 at Levels 3, 4, 5, 6), the experimenter refrained from asking the comprehension questions and administered an easier passage. If the child read the passage with a sufficient level of accuracy, the experimenter proceeded with the eight comprehension questions. The experimenter was not allowed to rephrase the question in any way or prompt the children or provide feedback. However, the children were permitted to refer back to the passage when answering the questions, and were encouraged to guess if they were not sure about the answer. Children's responses were recorded on a score sheet and voice-recorded for subsequent verification.

Children's answers to the comprehension questions were scored using the guidelines provided by the YARC. For some of the question items, the child's answer had to contain a certain key word to be scored as correct. In general, however, responses were marked as correct

[26] This does not hold for the Beginner Level passage and the Level 1 passage which were both fictional. The Beginner Level passage also has special administration rules which are not included here since the children in the present project were older and none of them was administered the Beginner Level passage.

if the gist was identical to that given in the answer key. The passage score was the total number of correctly answered questions out of eight. In order to derive a reading ability score, the test requires the children to read a second passage. The additional passage was selected on the basis of the child's score on the comprehension questions of the starting level passage. If they scored 4 or less they were administered the next passage at a lower level (e.g., Level 4 → Level 3) and if they scored 5 or more they moved to the passage at the next higher level (e.g., Level 5 → Level 6). The comprehension scores were summed across the two passages and were subsequently converted into an ability score which reflects both the child's raw score and the level of difficulty of the passages that were administered. Consequently, a raw score of e.g., 10 attained on passages 2 and 3 yield a lower ability score than the same raw score obtained on the more difficult passages 4 and 5. Finally, children's ability scores could be converted into standard scores (*M*=100, *SD*=15). Note that unlike other standardized (language) assessments, the standardization sample of the YARC included 14% children who spoke English as an additional language which is about the same amount as for primary school pupils in England reported in national statistics when the test was published (DCSF, 2009).

Table 16. *Overview of the different passages comprising Form A of the YARC.*

Difficulty Level	**Passage type**	**Topic**
Beginner Level	fictional	text about a girl putting on an outfit to go to a party
Level 1	fictional	text about a boy flying on an aeroplane for the first time
Level 2	non-fictional	text about robins (where they live, what they eat, etc.)
Level 3	fictional	text about a burglar that accidentally brakes into a policeman's house
Level 4	non-fictional	text about a type of lizard called Goanna (physical appearance, habitat, behaviour, etc.)
Level 5	fictional	text about a boy who is on a camping trip with his family and saves the breakfast from being eaten by a dog
Level 6	non-fictional	text about pirates in general and the fate of two female pirates in particular

Greek Reading comprehension

The two subtests of the reading comprehension component of the TEST-A (Panteliadou & Antoniou, 2007) were used to measure children's reading comprehension skills in Greek. The first task was a sentence matching task and consisted of four test items and one practice item. For each item, children had to read a set of five sentences and find the two that were equivalent in meaning (see Table 17, for an example). The final score was the total number of correctly identified sentence pairs out of a maximum of four. The second subtest of the reading comprehension component was the passage reading task. The subtest consisted of three passages that were between 97–127 words in length and of increasing difficulty (A, B, C). The first passage was fictional and the other two were non-fictional. Children were asked to read out the first passage printed on a card. Once they finished they were asked 7 multiple choice questions about the passage they just read (see Table 18, for further description of the questions). The multiple choice questions were again presented on a card, however, they were read out aloud by the experimenter. For each question, children had to choose one out of four options. Moreover, they were allowed to refer back to the passage when answering the questions. If the child provided at least three correct answers for a given passage, the experimenter proceeded with the next passage, otherwise testing was discontinued. The final score was the total number of correctly answered questions out of a maximum of 21. The TEST-A provides standardized norms for children from 8;9 to 14;9 years of age. Thus, composite scores for the reading comprehension component from the sentence matching and passage comprehension subtests could be converted into percentiles and Grade equivalents.

Table 17. *Practice item of the sentence matching subtest of the TEST-A.*

1	**Η δασκάλα μοίρασε τα βιβλία.**	**“The teacher distributed the books.”**
2	Η δασκάλα διόρθωσε τα βιβλία.	“The teacher corrected the books.”
3	**Τα βιβλία μοιράστηκαν από τη δασκάλα.**	**“The books were distributed by the teacher.”**
4	Τα βιβλία είναι καινούργια.	“The books are new.”
5	Η δασκάλα είναι αυστηρή.	“The teacher is strict.”

Table 18. *Overview of question types of the reading comprehension subtest of the TEST-A.*

i	Question probing factual information given in the text e.g., *Who decided to go and look for the treasure?*
ii	Question about the meaning of a particular word e.g., *What does X mean?*
iii	Question requiring the interpretation or paraphrase of a sentence from the passage. e.g., *How do you know that the children are happy?*
iv	Question probing the main topic/idea of the passage e.g., *Choose a suitable title.*
v	Question requiring the child to detect a wrong statement. e.g., *Which statement does not agree with the text?*
vi	Question requiring inference or the identification of abstract characteristics e.g., *How would you characterize X?*
vii	Question requiring evaluation of the passage or the identification of abstract characteristics e.g., *How would you characterize X?*

2.4 Measuring levels of biliteracy

Literacy comprises two major components, reading and writing. By definition, biliteracy is the ability to read and write in two languages. Recall that the development of writing skills is outside the scope of the present study, thus the terms literacy and biliteracy are used to refer to reading skills only. Although bilingualism and biliteracy are related constructs, they are clearly separable in that one does not necessarily entail the other. Measuring degrees of bilingualism in terms of language dominance has received considerable attention during recent years (e.g., Treffers-Daller & Silva-Corvalán, 2016). In the relevant literature, researchers generally agree that bilingualism is a multidimensional phenomenon that is best described by language proficiency and/or use (Luk & Bialystok, 2013; Treffers-Daller, 2016). However, there is little consensus on how to best operationalize these constructs and indices of bilingualism and language dominance have been calculated in different ways (Birdsong, 2016). In contrast to bilingualism, research on biliteracy is still in its infancy and only few studies have tried to measure biliteracy as a single outcome (Proctor & Silverman, 2011). Consequently, there is currently no commonly used index of biliteracy. In the present study, levels of biliteracy were measured in two different ways: 1) based on information from the questionnaires about the amount of formal schooling received (BIS; Biliteracy Index Schooling), and 2) based on the children's performance on the word reading measure[27] (BIR; Biliteracy Index Reading). Thus, the two indices reflect the two core aspects that have been shown to be central to the measurement of bilingualism with use (or experience) being indexed by amount of formal schooling and proficiency being indexed by task performance. Each index was calculated in two different ways. Following Treffers-Daller and Korybski (2016), the first calculation was done using the Edinburgh formula as presented in Birdsong (2016). The formula was initially developed within the study of handedness (Oldfield, 1971), and is calculated as the difference between scores for the two languages divided by the sum of the scores for the two languages with the resulting ratio being multiplied by 100 by convention. Hence, the index scores range from -100 to +100. The second calculation was adopted from Blom et al. (2014) who computed a bilingual proficiency score based on children's performance on vocabulary measures in the two languages. First, they calculated a balance score by dividing the higher score by the lower score. The balance score was subsequently subtracted from the average score for the vocabulary measures in the two languages to form the bilingual proficiency score. The advantage of this formula is that it retains information about raw scores and combines it with relativistic scores (i.e., the balance score). The following two subsections report the results from the calculations of the various indices for the bilingual sample. The four indices and the formulae by which they were calculated are summarized in Table 19.

[27] The decoding measure was chosen over the reading comprehension measure because the latter had a different format and range of difficulty in the two languages (English: open-ended questions vs. Greek: multiple choice questions).

Table 19. *Overview of the four biliteracy indices.*

Index	Measure	Formula
BIS1	*amount of schooling*	$\frac{\text{English} - \text{Greek}}{\text{English} + \text{Greek}} * 100$
BIR1	*reading performance*	
BIS2	*amount of schooling*	$\frac{\text{English} + \text{Greek}}{2} - \frac{\text{higher score}}{\text{lower score}}$
BIR2	*reading performance*	

2.4.1 Index based on schooling (BIS)

The biliteracy indices based on schooling were derived from the index scores for amount of formal schooling received in English and Greek[28] which had been calculated on the basis of relevant information obtained in the questionnaires (see section 2.2.3). The scores for amount of schooling were entered into the Edinburgh formula to compute the BIS raw scores. The English scores were always entered as the first term in the subtraction and Greek scores as the second term. Because English index scores were used as the 'baseline', positives scores reflect overall more literacy instruction in English, while negative scores emerge for children who have received more formal instruction in Greek. The average index score from this calculation was 27.2 (*SD*: 70.5) indicating that as a group, the children had received more formal instruction in English than in Greek (see Table 20). However, the direction of the difference in terms of amount of formal schooling was irrelevant for the present purposes, so the initial raw values were converted into absolute values to derive the BIS1 scores. Although information on the direction of the difference is lost, the interpretation of the index scores remains the same in the sense that values closer to 0 reflect equal amounts of formal schooling in the two languages, while higher values indicate increasingly unequal amounts of formal instruction. The mean for the BIS1 with absolute values was 71.8 (*SD:* 21.6) suggesting that the majority of the children had received fairly unequal amounts of schooling in the two languages. Figure 15 shows the distribution of BIS1 scores and the proportion of children who had received more instruction in English than in Greek and vice versa (i.e., the proportion of negative and positive raw scores). There were a handful of children who showed very high degrees of biliteracy (BIS1<20), 14 children had an index score between 40–65 and the remaining 31 children had very unbalanced literacy across the two languages with index scores of 75 or higher. From the 14 children with BIS1 scores in the middle range, 11 had more formal instruction in Greek and 3 had more instruction in English. Within the 31 children with very unequal amounts of schooling in the

[28] For the child who had received some instruction in a third language, the amount of instruction in this other language was not taken into account. Hence, the BIS for this child was based on amount of instruction received in English and Greek only.

two languages, 5 had more schooling in Greek than in English and for the remaining 26 children the opposite was the case.

Table 20. *Scores for the biliteracy indices based on schooling (BIS).*

	BIS (raw)	BIS1	BIS2
n	48	48	48
mean	27.2	71.8	231.5
SD	70.5	21.6	62.3
range	-90.9–96.6	8.5–96.6	117–338

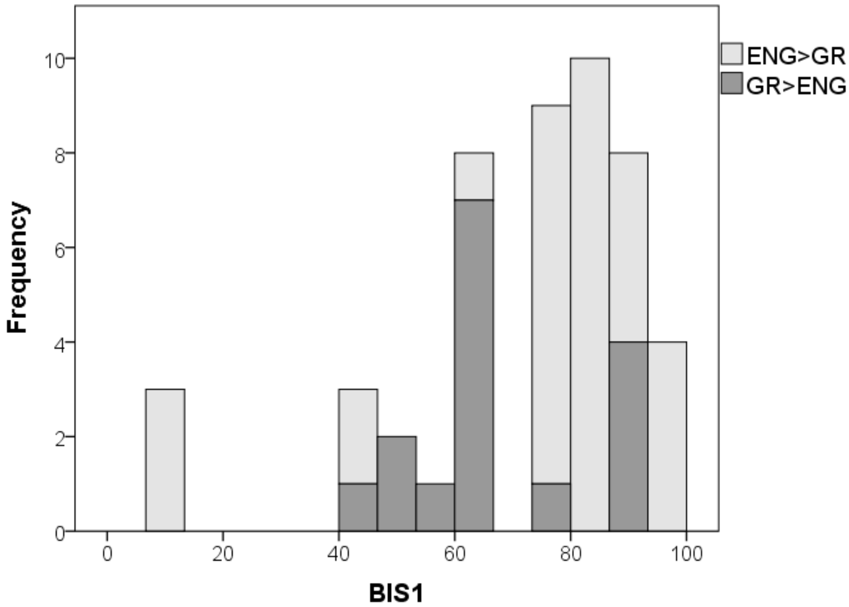


Figure 15. Distribution of BIS1 scores and proportion of children with more English vs. Greek schooling.

The second variant of the BIS was computed with the formula adopted from Blom et al. (2014). The group average for the BIS2 scores was 231.5 (*SD*: 62.3) (see Table 20). Recall that this index incorporates both raw scores and relativistic scores, so the interpretation is slightly different from the BIS1. The BIS2 reflects actual amount of schooling more so than it does relative amount, which is merely applied as a correction of the average score. Hence, higher index scores indicate overall more amount of formal schooling across both languages. The scores for the BIS2 showed a roughly normal distribution across the sample (see Figure 16). Moreover, the 16 children who had received more schooling in Greek than in English had BIS2 scores in the middle and upper range, while all the children with lower BIS2 scores had had more English schooling.

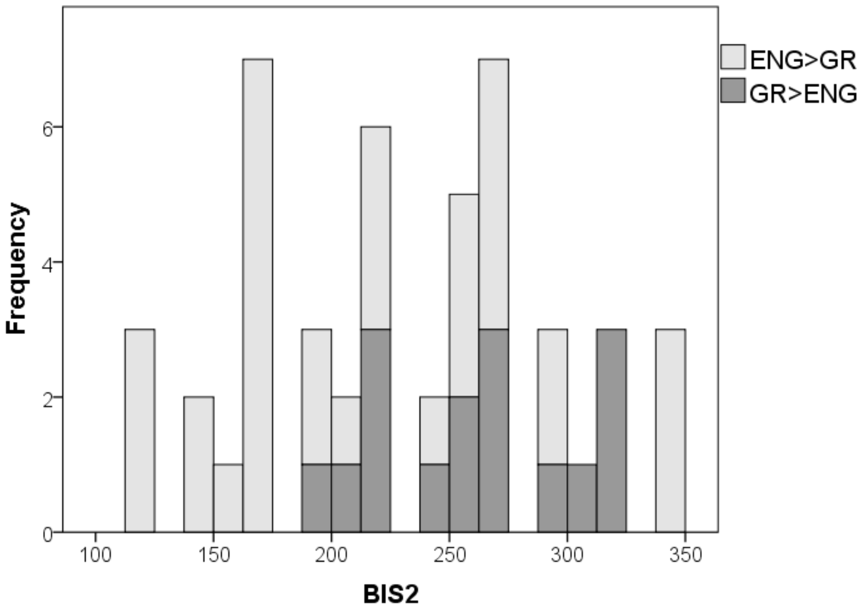


Figure 16. Distribution of BIS2 scores and proportion of children with more English vs. Greek schooling.

2.4.2 Index based on reading performance (BIR)

The second set of biliteracy indices was calculated on the basis of children's performance on the decoding measures. Recall that the single word reading test in English only included real words while in Greek the task included both real words and pseudowords. To make the measures as similar as possible across languages, only accuracy on real words was included for Greek. Children's scores were converted into percentage scores to correct for differences in scale (60 items in English vs. 53 items in Greek). The percentage scores for single word reading were entered into the Edinburgh formula to compute the BIR raw scores. The group mean was 9.5 (*SD:* 24.2) suggesting that the children had very similar levels of decoding skills in the two languages with overall slightly higher scores in English (see Table 21). The raw values were again converted into absolute values to derive the BIR1 scores. The mean for BIR1 was 14.9 (*SD*: 21.2) confirming that the differences in word reading skills between the two languages were very small (see Table 21). Figure 17 shows the distribution of the BIR1 scores and the proportion of children who scored higher on the decoding measure in English than in Greek and vice versa (i.e., the proportion of positive and negative raw scores). The vast majority of the children (n=41) had very similar levels of decoding skills in Greek and English with BIR1 scores between 0–20. Out of these 41 children, 21 had slightly better decoding skills in Greek and the remaining 20 had marginally better decoding skills in English. Three children had BIR1 scores between 20–40, with one child showing higher decoding skills in Greek and two children exhibiting superior performance in English. The remaining six children all had better decoding skills in English than in Greek. Three had BIR1 scores between 50–60, and three had scores between 75–85.

Table 21. *Scores for the biliteracy indices based on reading performance (BIR).*

	BIR (raw)	BIR1	BIR2
n	50	50	50
mean	9.5	14.9	75.5
SD	24.2	21.2	19.5
range	-20.3–82.1	0.3–82.1	9.3–93.9

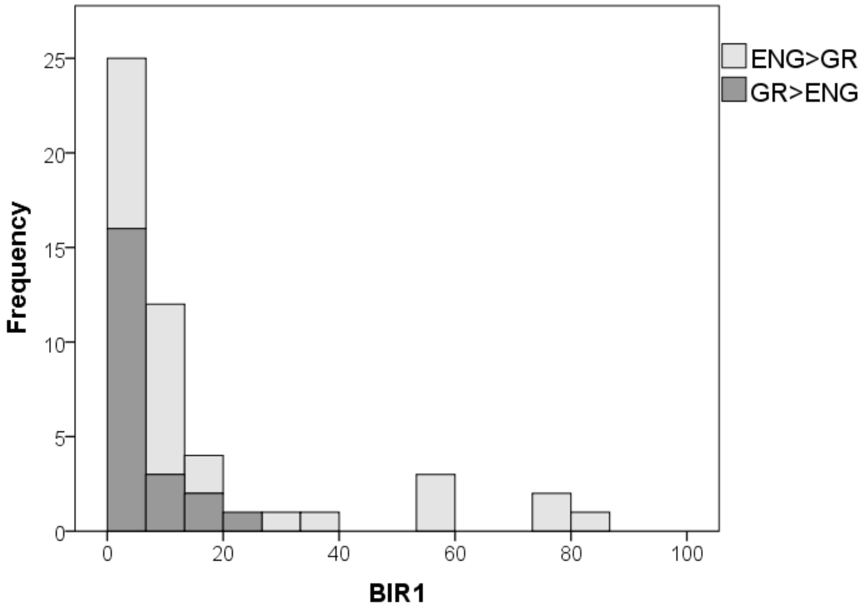


Figure 17. Distribution of BIR1 scores and proportion of children with higher scores on English vs. Greek decoding.

The calculation of the BIR2 scores yielded a group average of 75.5 (*SD*: 19.5) suggesting that overall, children scored quite high on the word reading test in both languages (see Table 21). Inspection of the histogram revealed that the distribution of BIR2 scores was skewed to the left (see Figure 18). More than half of the children (n=27) had a BIR2 score of >80 and for 16 children, the scores were between 60–80. The remaining seven children all had BIR2 scores below 60 (three children between 40–60, two children between 20–40 and two children between 0–20), indicating that they had fairly low levels of decoding in one or both of the languages. The 22 children who scored higher on the Greek decoding measure than on the English one all had BIR2 scores above 60 (four between 60–80, and 18 above 80).

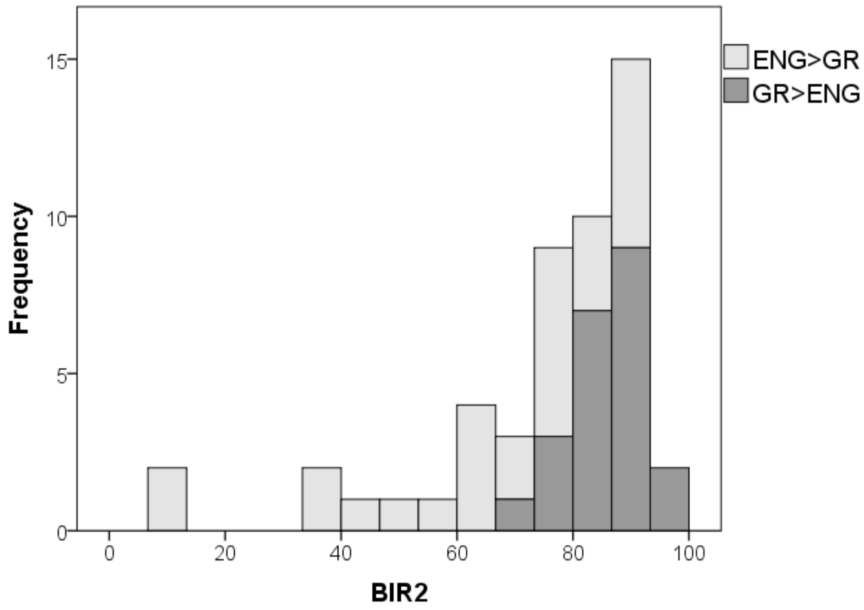


Figure 18. Distribution of BIR2 scores and proportion of children with higher scores on English vs. Greek decoding.

2.5 Procedure

Prior to the start of the data collection, the study was reviewed by the University of Reading Research Ethics committee and was given a favourable ethical opinion for conduct. The study ran between April 2014 and June 2016 and took place in the UK and Greece. Most of the data were collected by a near-native speaker of English and Greek. Two trained experimenters who were native speakers of Greek aided with the data collection of the L1-Greek children in Greece, and another two trained experimenters who were also native speakers of Greek helped with the collection of the Greek data from the bilinguals in the UK. In terms of testing location, children that were recruited directly via their primary school were assessed in a quiet room or corner of the school during school hours[29]. This was the case for all the bilingual children recruited from the Greek school in London, approximately half of the children from the L1-English sample, and all of the children from the L1-Greek sample. For the remaining children, an appointment was arranged to take place either at the Psychology department of the University or at the children's homes during after-school hours, weekends or half terms. The test battery for the monolingual Greek and English children lasted approximately 90 minutes and was divided into two sessions of around 45 minutes each. The bilingual children were assessed in both of their languages over three to four sessions lasting about one hour each. The sessions for the monolinguals were no more than two weeks apart, while the sessions for the

[29] Some of the L1-Greek children attended the 'all day' programme of their school and were thus sometimes assessed after regular school hours.

bilinguals were spread over a maximum of six weeks. The bilingual children could choose in which language they wanted to do the tasks first which was typically the language they felt more comfortable with. The tasks were presented in a semi-fixed order that attempted to balance task demands. The participating children were allowed to take short brakes between tasks if they wished to do so. Finally, the children were rewarded for their participation with small gifts (e.g., pencils, stickers, etc.) or snacks after each session.

CHAPTER 3 – GROUP & LANGUAGE COMPARISONS

3.1 Research hypotheses & predictions

The aim of this chapter is to examine the Greek-English bilingual children's strengths and weaknesses in the domains of language, literacy, and cognition. Previous research that has compared the performance of monolinguals and bilinguals on different tasks has shown asymmetries both within and across domains. For example, large group differences in favour of monolinguals have been reported for measures of oral language skills, particularly expressive vocabulary, while no such differences emerge for basic literacy skills. However, the presence or absence of significant group differences between monolinguals and bilinguals in the various domains depends on a number of factors. One of these factors is language status, i.e., whether the bilingual children's language skills are assessed in the majority or the minority language. Generally, group differences are more marked in the bilingual children's minority language, especially for skills that require language-specific knowledge. On the other hand, there have been a lot of conflicting findings in the literature, suggesting that the results depend heavily on task-specifics of the measures used to assess the various skills of interest. Hence, more studies are needed that provide systematic assessments of bilingual children's language skills in both languages across different domains. The current study adds to the existing literature by comparing bilingual and monolingual children's performances on a range of cognitive tasks, as well as linguistic measures in both languages. Bilingual profile effects were further investigated by comparing bilingual children's language and literacy skills across the two languages. The specific research questions addressed in this chapter are as follows:

i. *Are there any group differences in non-verbal IQ and expressive vocabulary scores?*

The first step was to compare the three groups on Raven's scores to ascertain that the comparisons between the bilinguals and the monolinguals on the various measures are not confounded by differences in non-verbal IQ. As mentioned in chapter 2, the three groups were comparable in SES, so no differences are anticipated for this measure. By contrast, bilinguals tend to score lower on measures of vocabulary than their monolingual peers in each of their languages (e.g., Bialystok et al., 2010), although when both languages are considered, the size of the total conceptual vocabulary is the same or even larger in bilinguals (Pearson et al., 1993). Thus, the monolingual control groups are predicted to outperform the bilinguals on the measure of expressive vocabulary in both languages, but especially in the minority language Greek. Finally, no difference in expressive vocabulary scores is predicted between the two monolingual control groups given the comparability of the tests used in the two languages.

ii. *Do the bilingual children differ from their monolingual peers in oral language skills in the two languages English and Greek (after controlling for vocabulary)?*

Although bilinguals are known to score lower on vocabulary measures than their monolingual peers in each language, research has shown that grammatical skills are largely unaffected by bilingualism. Nevertheless, language processing in bilinguals is more effortful due to the simultaneous activation of both languages which leads to lexical competition (e.g., Marian, Spivey & Hirsch, 2003; van Heuven, Dijkstra & Grainger, 1998). Sentence repetition tasks (SRTs) tap both vocabulary and grammatical skills, and place high processing demands on working memory. As a consequence, the bilingual children in the current study are predicted to score lower than their monolingual peers in terms of overall accuracy in both languages. However, in line with previous research (e.g., Komeili & Marshall, 2013), any differences between monolinguals and bilinguals will be reduced, or even disappear, after statistically controlling for vocabulary. In contrast, grammaticality and correct use of the target structure implicate little or no lexical skills. Hence, for the majority language English, the bilinguals are expected to perform on a par with their monolingual peers on these two measures. For the minority language Greek, on the other hand, there are more likely to be group differences given that the majority of the children receive relatively little input in Greek, which might not have been sufficient to acquire the more difficult grammatical structures in Greek yet. In any case, the group differences are expected to be smaller once lexical skills are controlled for. Research focusing on listening comprehension skills of bilinguals has shown significant effects of bilingualism with superior performance by monolinguals (Droop & Verhoeven, 2003; Hutchison, Whiteley, Smith & Connors, 2003). Thus, it is predicted that the monolinguals will outperform the bilinguals in both languages, but even more so in the minority language Greek. As with the other oral language measures, the size of the effect is expected to be considerably smaller once vocabulary knowledge is accounted for.

iii. *Do the bilingual children differ from their monolingual peers in executive function abilities?*

Early studies on the relationship between bilingualism and executive function skills suggested a bilingual advantage in inhibitory control (e.g., Bialystok, 1999; Bialystok & Martin, 2004; Bialystok & Viswanathan, 2009). More recently, researchers have also argued for a link between bilingualism and superior task switching abilities (e.g., Bialystok & Barac, 2012; Wiseheart et al., 2016). Moreover, there is some evidence for a bilingual advantage in working memory and updating skills (e.g., Blom et al., 2014; Marinis et al., under review; Morales et al., 2013), although numerous studies have failed to observe any group differences as a function of bilingualism (e.g., Engel de Abreu, 2011; Ratiu & Azuma, 2015). Recent reviews of the relevant literature have shown that overall, the findings are highly inconsistent and that the results might be confounded by a publication bias (Klein, 2016; Paap & Greenberg, 2013; von Bastian, Souza & Gade, 2016). One factor that has been suggested to explain the different findings across studies is task complexity, in that bilingual advantages only emerge in tasks that place high demands on executive function skills (Costa, Hernandez, Costa-Faidella & Sebastian-Galles, 2009; Hofweber, Marinis & Treffers-Daller, 2016; Marinis et al., under review).

In light of the mixed findings, the predictions as to which EF measures might show effects of bilingualism can only be tentative. Most studies that have found a bilingual advantage have used complex tasks that require participants to inhibit conflicting information. Hence, a bilingual advantage is likely to emerge in the Global-Local task which was designed to tap inhibition and task switching abilities. If bilingualism affects WM skills, superior performance on part of the bilinguals is expected on a measure of non-verbal WM, namely the Mr. X task. In contrast, the digit backwards task measures verbal WM and thus, includes a language component. Consequently, any effects of bilingualism on WM skills might be obscured by the bilingual children’s lower language proficiency since verbally mediated assessments of working memory are dependent on vocabulary knowledge and verbal ability in general (Nation, Adams, Bowyer-Crane & Snowling, 1999). However, if bilingualism enhances WM skills, a bilingual advantage in verbal WM should emerge after statistically controlling for language proficiency. Similarly, the 2-back task employed digits and therefore, includes a language component. As such, no group differences are expected between monolinguals and bilinguals unless the bilingual children’s lower language proficiency is controlled for. Finally, it is anticipated that the monolingual children will outperform the bilinguals on the letter fluency task due to its strong verbal component and the fact that bilingual children typically have smaller vocabularies in each of their two languages than their monolingual peers in the respective languages. However, in line with previous research (e.g., Bialystok, Craik & Luk, 2008; Luo, Luk & Bialystok, 2010), the difference between monolinguals and bilinguals should disappear when vocabulary is controlled for.

iv. Do the bilingual children differ from their monolingual peers in literacy skills in the two languages, English and Greek?

Only a few studies have compared monolingual and bilingual children’s performance on rapid serial naming tasks. In a longitudinal study, Geva et al. (2000) found that children who were learning English as an L2 were significantly slower on a measure of rapid serial naming than their monolingual peers at the end of grade 1. However, the difference had disappeared by the beginning of grade 2. Hence, for the measure of rapid naming, the prediction is that there will be no difference between the monolinguals and the bilinguals. This is because although the bilinguals show slower lexical access (due to interference from the other language or due to weaker ‘links’ or ‘neural connections’), rapid naming also implicates executive function skills (Protopapas, Altani & Georgiou, 2013), which are argued to be enhanced in bilinguals. Thus, it is hypothesized that the slower lexical access and the enhanced EF skills will cancel each other out, leading to equal performance by the two groups. Previous research comparing decoding skills of monolinguals and bilinguals has yielded mixed results, but overall there seems to be little evidence that bilingualism affects word reading skills positively or negatively (Melby-Lervåg & Lervåg, 2014). Hence, no group difference is anticipated for the measure of decoding skills. Moreover, bilinguals are predicted to outperform monolinguals on single word reading once lexical skills are controlled for (Burgoyne, Kelly, Whiteley & Spooner, 2009; Burgoyne et al., 2011). Turning to reading comprehension, a number of studies have found lower performance of bilinguals compared to their monolingual peers (e.g., Babayiğit, 2014; Thomas & Collier, 2002; Verhoeven, 2000). Thus, the prediction is for the monolinguals to outperform the bilinguals on reading comprehension in both languages. Again the size of the effect is expected to be attenuated once vocabulary is taken into account. Performance on the visual lexical decision task is largely dependent on decoding skills and vocabulary and to a lesser degree on orthographic knowledge. Given the predicted differences in vocabulary in favour of the monolinguals, the monolinguals are expected to show better performance on the lexical decision task than the bilinguals in both English and Greek. However, the differences are predicted to disappear once individual differences in vocabulary have been accounted for.

v. *How does the bilingual children’s performance in the minority language compare to performance in the majority language?*

Bilinguals who are equally proficient in their two languages across different domains are extremely rare (Treffers-Daller, 2016). The bilingual children in the current sample were all residing in the UK and the majority went to English mainstream schools. In addition, the analysis of the questionnaires showed that the bilingual children had received more formal instruction in English than in Greek and that English was used more frequently than Greek on a daily basis (see sections 2.2.2 & 2.2.3). Given the status of English as the majority language, it is predicted that overall, the bilingual children’s performances on the English measures will exceed performances on Greek measures. However, larger differences across the two languages are expected for measures that tap primarily language-specific knowledge, such as vocabulary, sentence repetition, narrative microstructure and listening comprehension. On the other hand, scores on measures that include a relatively large cognitive component, but less language-specific skills and knowledge are expected to be more similar across languages (e.g., verbal WM, decoding). Moreover, tasks that tap expressive language skills (e.g., vocabulary, story production) are predicted to show larger crosslinguistic differences than tasks that assess more receptive language skills (e.g., lexical decision, listening comprehension). Finally, the extent to which the various measures tap language-specific vs. language-invariant skills should also be reflected in the crosslinguistic correlations of the various scores (Cárdenas-Hagan, Carlson & Pollard-Durodola, 2007). Thus, stronger positive correlations are anticipated for tasks with larger cognitive components, while negative or no correlations are predicted for measures that tap primarily language specific-knowledge.

3.2 Analyses

The data were analysed with SPSS software (Statistical Package for the Social Sciences version 21; IBM, 2012). A series of analyses of variance (ANOVA) and covariance (ANCOVA) was carried out in order to address the first four research questions posed in this chapter. The first step was to determine whether the groups differed on the baseline measures of non-verbal IQ and vocabulary. Baseline measures that showed a significant group difference were entered as covariates in the subsequent analyses of the experimental measures. Recall that the children's age ranged from 7 to 12 years and the Greek monolingual control group was significantly older than the other two groups. Hence, age was used as a covariate in all of the group comparisons. Levene's test was used to test for equality of variances. Finally, each analysis was re-run including all two-way and three-way interactions between the independent variable (group) and the covariates to make sure that the data met the assumption regarding homogeneity of regression slopes. The fifth research question was investigated by running a series of paired-samples *t*-tests to compare the bilingual children's performances in the two languages. Finally, a correlational analysis was carried out to examine any cross-linguistic relationships between the bilingual children's performances in English and Greek.

3.3 Results: Group comparisons for baseline measures

Table 22 gives an overview of the bilingual and monolingual children's raw scores on the Raven's Coloured Progressive Matrices (*n, M, SD, range*) as well as expressive vocabulary scores in English and Greek. The descriptive statistics suggest equal performance by the three groups on the Raven's while the bilinguals seem to score lower than their monolingual peers on the measure of expressive vocabulary, especially in the minority language Greek.

Table 22. *Scores on Raven's Coloured Progressive Matrices and expressive vocabulary in English and Greek.*

		Bilinguals	L1-English	L1-Greek
Raven's	*n*	50	58	66
max. 36	*mean*	31.6	30.0	30.9
	SD	3.5	3.8	3.7
	range	21-36	19-36	20-36
English Vocabulary	*n*	50	58	
max. 50	*mean*	38.1	43.3	
	SD	6.5	2.6	
	range	24-48	36-49	
Greek Vocabulary	*n*	50		66
max. 50	*mean*	30.4		43.2
	SD	10.2		3.8
	range	6-48		31-50

In terms of non-verbal abilities, the ANCOVA with age as covariate revealed no group differences on Raven's raw scores ($F(2,170)=2.35$, $MSE=12.5$, $p=.098$, $\eta_p^2=.027$) confirming that the three groups were well matched on non-verbal IQ[30]. For expressive vocabulary scores in English, the ANCOVA with age as covariate showed that the English monolinguals scored significantly higher than the bilinguals ($F(1,105)=30.53$, $MSE=23.6$, $p<.001$, $\eta_p^2=.225$). The ANCOVA for expressive vocabulary scores in Greek yielded a reliable group effect with the Greek monolinguals outperforming the bilinguals ($F(1,113)=75.68$, $MSE=45.4$, $p<.001$, $\eta_p^2=.401$). Note that the effect was almost twice as big in Greek compared to English ($\eta_p^2=.401$ for Greek vs. $\eta_p^2=.225$ for English). Considering just the two monolingual groups, the ANCOVA using age as a covariate showed no significant group effect ($F(1,121)=2.92$, $MSE=9.8$, $p=.09$, $\eta_p^2=.024$) suggesting that the two monolingual control groups were equivalent in terms of lexical skills. Taken together, the results indicate that the gap between the bilinguals and the monolinguals is smaller for lexical skills in the majority language English than in the minority language Greek (see Figure 19).

[30] The analysis using the standard scores from the Raven's yielded the same results ($F(2,170)=2.42$, $MSE=222.2$, $p=.092$, $\eta_p^2=.028$).

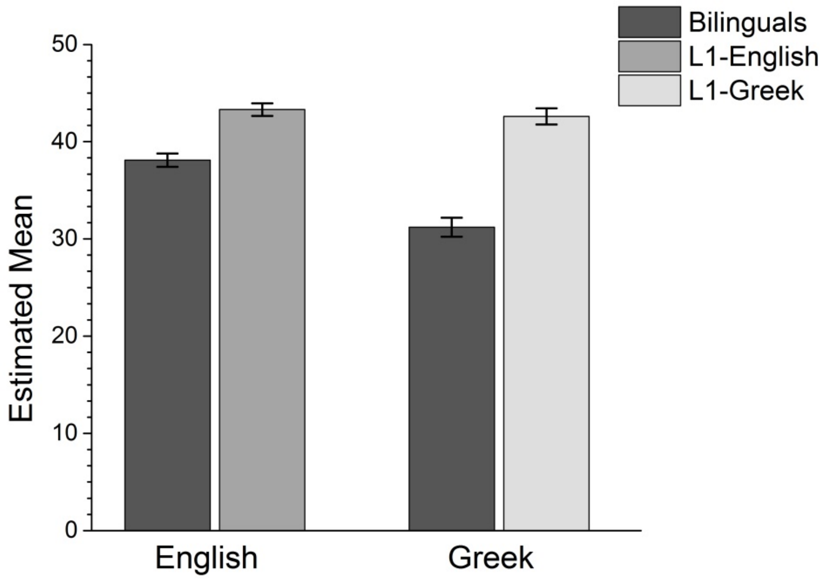


Figure 19. Estimated means for vocabulary scores in English and Greek.

3.4 Results: Group comparisons for measures of oral language skills

A series of ANCOVAs was run with age as a covariate and group as between-subjects factor to test for differences between the bilinguals and the monolinguals on measures of oral language skills in English and Greek. The dependent measures were the three scores from the sentence repetition tasks and the scores for the comprehension questions of the narratives. Given that the bilinguals scored lower than their monolingual peers on the vocabulary measure in both languages, the analyses were re-run with vocabulary as an additional covariate to ascertain that any significant differences on the more global oral language measures are not confounded by lexical skills.

3.4.1 English

Table 23 presents the scores for overall accuracy, grammaticality and correct use of the structure from the English sentence repetition task. For overall accuracy, the ANCOVA with age as the only covariate showed a significant group effect with the monolinguals scoring higher than the bilinguals ($F(1,105)=9.12$, $MSE=43.8$, $p=.003$, $\eta_p^2=.080$). However, when vocabulary scores were included as an additional covariate, the group difference disappeared ($F(1,104)=0.08$, $MSE=33.4$, $p=.777$, $\eta_p^2=.001$). For grammaticality scores, the ANCOVA with age as covariate yielded a significant group difference with the English monolinguals outperforming the bilinguals ($F(1,105)=10.59$, $MSE=25.2$, $p=.002$, $\eta_p^2=.092$). However, adding vocabulary scores as a covariate yielded no significant group effect ($F(1,104)=0.03$, $MSE=15.7$, $p=.855$, $\eta_p^2<.001$). For structure scores, the ANCOVA with age as the sole covariate yielded again a significant group effect in favour of the monolinguals ($F(1,105)=9.34$, $MSE=20.2$,

p.003, η_p^2=.082). The inclusion of vocabulary as an additional covariate yielded no significant differences between groups (F(1,104)=0.09, MSE=15.3, p=.766, η_p^2=.001). Figure 20 shows the estimated group means for the set of analyses that included age as a covariate, and the set that included both age and vocabulary scores as covariates.

Table 23. *Overall accuracy, grammaticality and structure scores for the English SRT.*

		Bilinguals	**L1-English**
Overall accuracy	*n*	50	58
	mean	89.5	93.4
	SD	7.9	5.3
	range	64.4-98.9	73.3-100
Grammaticality	*n*	50	58
	mean	95.3	98.7
	SD	7.2	2.0
	range	60.0-100	93.3-100
Structure	*n*	50	58
	mean	95.9	98.6
	SD	5.9	2.8
	range	73.3-100	86.7-100

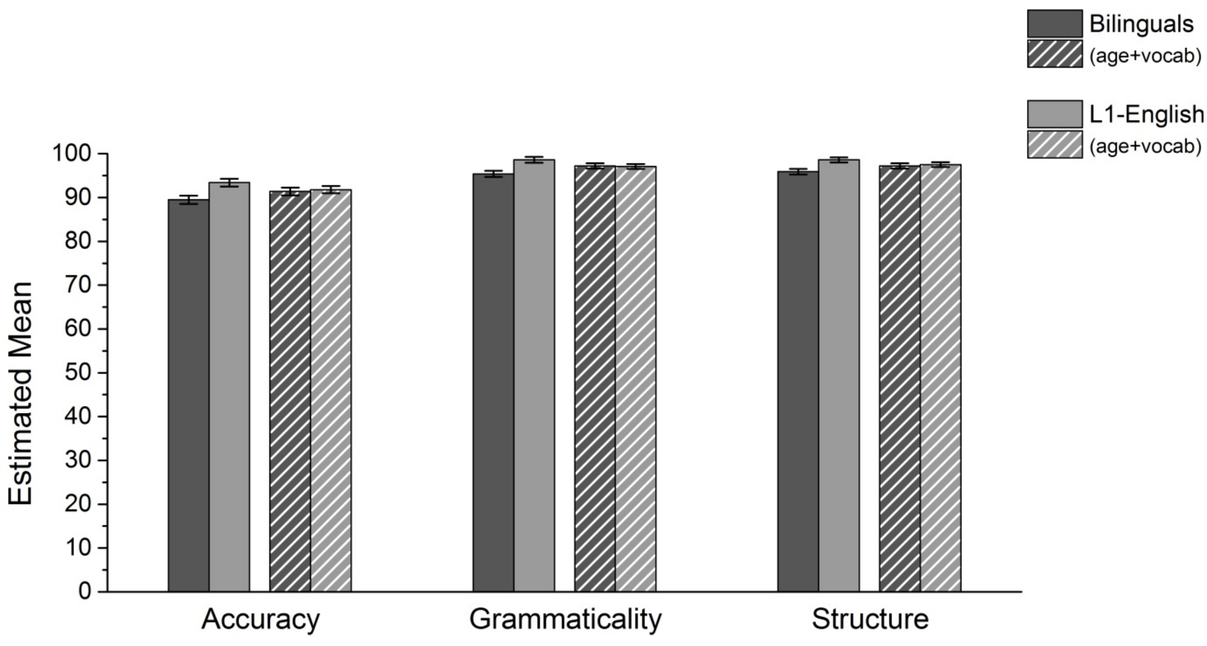


Figure 20. Estimated means for SRT scores in English.

The scores for the comprehension questions (CQ) of the oral narratives are given in Table 24. The ANCOVA with age as a covariate yielded no significant effect of group for total scores (F(1,105)=0.12, MSE=31.4, p=.725, η_p^2=.001). The inclusion of vocabulary as an additional covariate did not change the results (F(1,104)=0.54, MSE=31.5, p.463, η_p^2=.005). To test whether the groups differed on the two different types of comprehension questions, separate analyses were run for questions tapping factual information and for questions probing mental states of characters. For factual comprehension questions, the ANCOVA with age as covariate produced no significant group effect ($F(1,105)=0.64$, $MSE=38.1$, $p=.424$, $\eta_p^2=.006$). The inclusion of vocabulary as an additional covariate did not yield a significant group effect either ($F(1,104)=0.29$, $MSE=38.4$, $p=.593$, $\eta_p^2=.003$). For comprehension questions about mental states of characters, the ANCOVA with age as covariate showed no significant difference between groups ($F(1,105)=0.02$, $MSE=60.1$, $p=.898$, $\eta_p^2<.001$). The results did not change with the inclusion of vocabulary as an additional covariate ($F(1,104)=0.37$, $MSE=59.3$, $p=.544$, $\eta_p^2=.004$). The estimated group means for comprehension question scores for the two sets of analyses (ANCOVA with vocabulary; ANCOVA with age and vocabulary) are shown in Figure 21.

Table 24. *Scores for the comprehension questions from the listening comprehension task in English.*

		Bilinguals	**L1-English**
CQ total	*n*	50	58
	mean	92.0	91.5
	SD	6.1	5.1
	range	75.9-100	72.4-100
CQ factual	*n*	50	58
	mean	94.7	93.6
	SD	6.7	5.6
	range	71.4-100	78.6-100
CQ mental states	*n*	50	58
	mean	89.3	89.5
	SD	8.2	7.3
	range	66.7-100	66.7-100

Note. CQ = comprehension questions

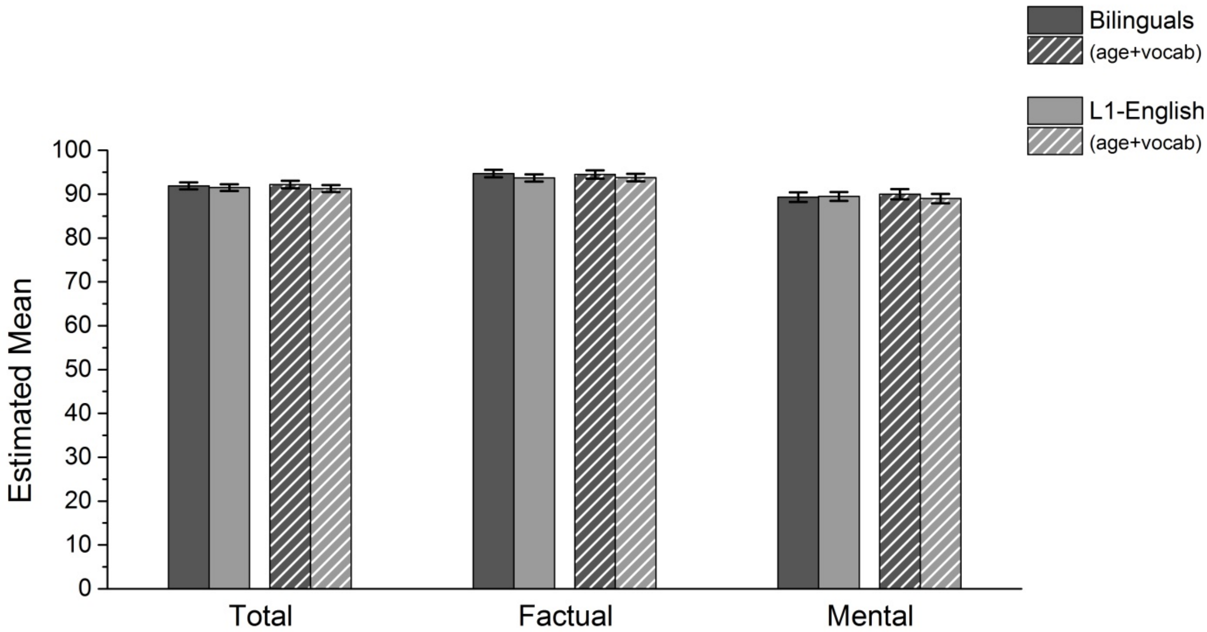


Figure 21. Estimated means for scores on the comprehension questions in English.

3.4.2 Greek

Table 25 presents the scores for overall accuracy, grammaticality and correct use of the target structure for the Greek SRT. The group means for the bilinguals are based on 48 children. This is because two of the bilingual children could not complete the task due to their low proficiency in Greek. For overall accuracy, the ANCOVA with age as a covariate showed a significant group effect with higher scores for the Greek monolinguals ($F(1,111)=27.64$, $MSE=353.9$, $p<.001$, $\eta_p^2=.199$). However, the inclusion of vocabulary as an additional covariate yielded no significant difference between groups ($F(1,110)=1.30$, $MSE=173.7$, $p=.257$, $\eta_p^2=.012$). For grammaticality scores, the ANCOVA with age as a covariate yielded again a significant effect of group with higher performance on part of the Greek monolinguals ($F(1,111)=17.80$, $MSE=141.3$, $p<.001$, $\eta_p^2=.138$). Adding vocabulary as a covariate in the analysis resulted in no significant group difference ($F(1,110)=0.49$, $MSE=96.9$, $p.484$, $\eta_p^2=.004$). For structure scores, the ANCOVA with age as the sole covariate showed again a significant group effect in favour of the monolinguals ($F(1,111)=21.61$, $MSE=249.2$, $p<.001$, $\eta_p^2=.163$). When vocabulary was included in the analysis as an additional covariate the group effect was not significant ($F(1,110)=1.10$, $MSE=145.9$, $p=.297$, $\eta_p^2=.010$). Figure 22 shows the estimated group means for the three measures from the Greek SRT.

Table 25. *Overall accuracy, grammaticality and structure scores for the Greek SRT.*

		Bilinguals	**L1-Greek**
Overall accuracy	*n*	48	66
	mean	61.8	84.9
	SD	27.4	13.1
	range	3.1-100	32.3-100
Grammaticality	*n*	48	66
	mean	81.8	93.6
	SD	17.3	7.6
	range	21.9-100	59.4-100
Structure	*n*	48	66
	mean	80.0	95.9
	SD	24.0	5.4
	range	9.4-100	65.6-100

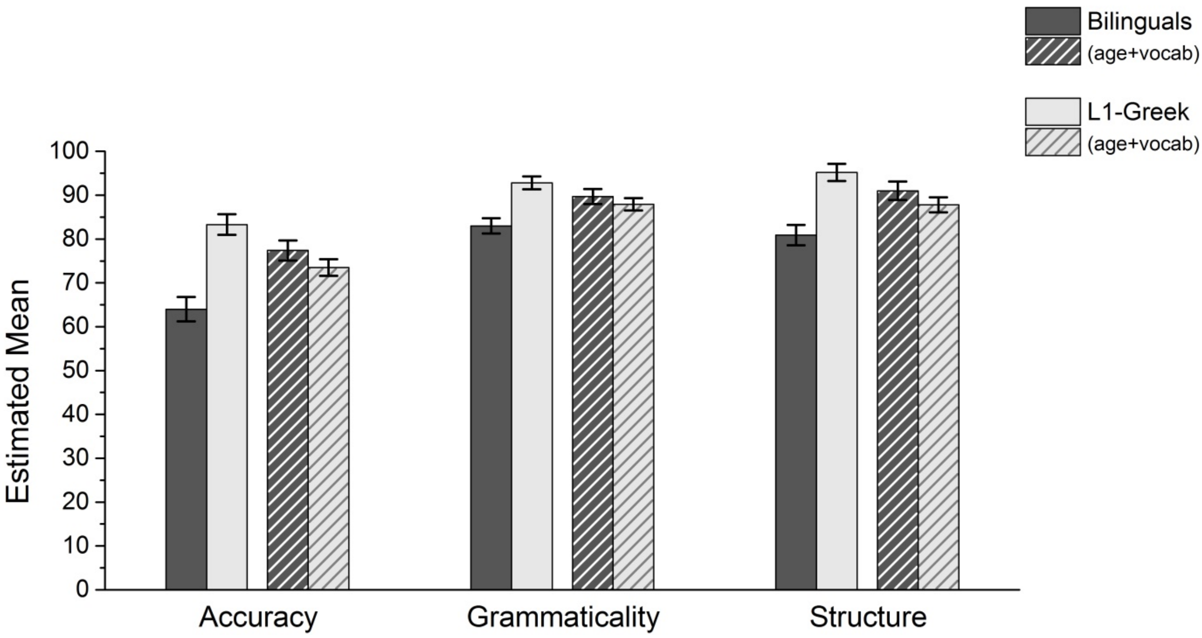


Figure 22. Estimated means for SRT scores in Greek.

The scores for the comprehension questions for the oral narratives in Greek are presented in Table 26. The means for the Greek monolinguals are based on 65 children because of data loss for one child due to equipment malfunction. For total scores on the comprehension questions in Greek, the ANCOVA with age as a covariate yielded a significant group effect with the Greek monolinguals outperforming the bilinguals (F(1,112)=18.48, *MSE*=60.5, p<.001, η_p^2=.142). However, when vocabulary scores were added as a covariate the group difference was not significant anymore (F(1,111)=3.11, *MSE*=57.5, p=.081, η_p^2=.027). Separate ANCOVAs were run for questions about factual information and for questions probing mental states of characters to see whether the results differed as a function of question type. For questions about factual information, the ANCOVA with age as a covariate showed a significant group effect with higher scores for the Greek monolinguals (F(1,112)=10.01, MSE=66.9, p=.002, η_p^2=.082). When vocabulary was included as an additional covariate, there was no significant difference between groups (F(1,111)=2.34, MSE=66.2, p=.129, η_p^2=.021). For questions about mental states of characters, the ANCOVA with age as the sole covariate showed a significant effect of group with the Greek monolinguals scoring higher than the bilinguals (F(1,112)=15.48, MSE=102.9, p<.001, η_p^2=.121). However, when vocabulary was added as a covariate, there was no significant group effect (F(1,111)=1.96, MSE=97.2, p=.164, η_p^2=.017). The estimated group means for scores on the comprehension questions are depicted in Figure 23.

Table 26. *Scores for the comprehension questions from the listening comprehension task in Greek.*

		Bilinguals	**L1-English**
CQ total	*n*	50	65
	mean	87.1	93.8
	SD	10.1	5.3
	range	51.7-100	79.3-100
CQ factual	*n*	50	65
	mean	89.6	95.5
	SD	10.6	6.0
	range	64.3-100	78.6-100
CQ mental states	*n*	50	65
	mean	84.7	92.1
	SD	12.8	7.4
	range	40-100	73.3-100

Note. CQ = comprehension questions

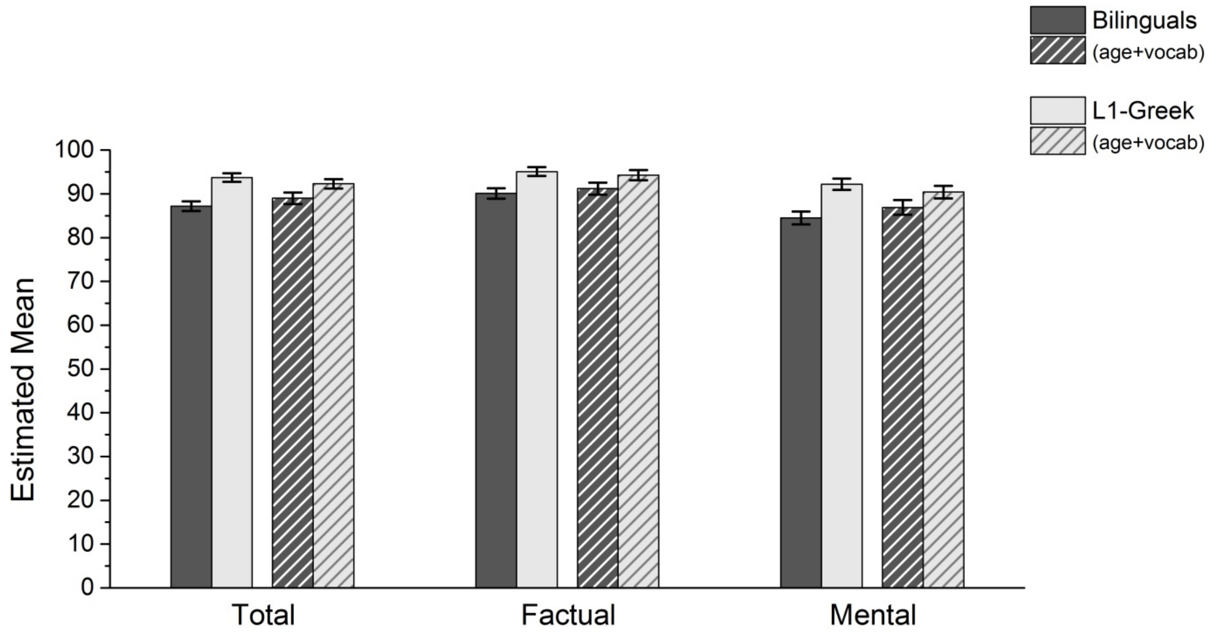


Figure 23. Estimated means for scores on the comprehension questions in Greek.

3.5 Results: Group comparisons for measures of executive function skills

A series of ANCOVAs was run to examine whether there were any group differences between monolinguals and bilinguals on the measures of executive function skills. The analyses of EF measures derived from the tasks that used non-verbal stimuli (i.e., visual working memory, inhibition and switching) included age as a covariate to control for age differences between groups. For the tasks that included a verbal component (i.e., updating, verbal working memory and letter fluency), the analyses were re-run with vocabulary as an additional covariate to control for differences in lexical skills.

Table 27 gives an overview of the bilingual and monolingual children's scores on the non-verbal measures of executive function skills. For the measure of visuospatial WM (i.e., scores on the Mr. X task), the ANCOVA with age as a covariate showed no significant group effect (F(2,170)=0.54, MSE=22.7, p=.582, η_p^2=.006). The three groups did not differ in visuospatial WM abilities. The analyses of the Global-Local task (GLT) is based on a subset of 172 children (bilinguals: 50, L1-English: 58 and L1-Greek: 64) due to technical problems that resulted in the loss of the data for two children from the Greek monolingual control group. The ANCOVA with age as covariate showed no significant group effect for overall accuracy on the GLT (F(2,168)=0.68, MSE=47.3, p=.510, η_p^2=.008). As mentioned in the methodology chapter, the GLT offers two measures of executive function skills, inhibitory control, measured in terms of the size of the congruency effect and switching, indexed by the switching cost. With regard to the congruency effect, the ANCOVA with age as a covariate revealed a significant group effect (F(2,168)=3.558, MSE=15,383, p=.031, η_p^2=.041). Post hoc comparisons showed that the congruency effect was significantly smaller for the L1-Greek compared to the bilinguals (*p*=.034), while the L1-English did not differ from the other two groups (both *p*s>.05). Thus, the L1-Greek were better able to inhibit conflicting information in incongruent trials compared to the bilinguals. The same analysis was performed with the size of the switching cost as dependent variable. The ANCOVA with age as covariate did not reveal any significant group differences ($F(2,168)=1.30$, $MSE=340{,}878$, $p=.274$, $\eta_p^2=.015$). Taken together, the present results do not provide any evidence for a bilingual advantage on non-verbal executive function measures[31]. Figure 24 shows the estimated group means for the non-verbal EF measures for the three groups.

Table 27. *Scores for the non-verbal executive function measures.*

		Bilinguals	**L1-English**	**L1-Greek**
Visuospatial WM	*n*	50	58	66
	mean	16.5	15.0	17
	SD	5.6	4.1	5.4
	range	5–35	6–26	4–31
GLT accuracy	*n*	50	58	64
	mean	93.5%	94.6%	93.1%
	SD	6.1	4.2	9.0
	range	66.7–100	82–99.5	53.6–99.5
Congruency effect (Inhibition)	*n*	50	58	64
	median	170ms	158ms	100ms
	SD	127.5	105.1	137.8
	range	-234.5–492.5	-40.0–469.0	-309.5–424.5
Switching cost	*n*	50	58	64
	median	1241ms	1247ms	1295ms
	SD	552.0	475.9	727.8
	range	114.5–2874.0	499.0–2941.0	-111.0–4017.0

Note. WM = working memory; GLT = Global-Local task

[31] Some additional analyses were run to test whether the children showed a bias for either global or local trials. Thus, level (global, local) was added as a within-subjects factor and order (global first, local first) was included as a between-subjects factor in addition to group (bilinguals, L1-English, L1-Greek). The results for accuracy showed a significant two-way interaction between level and order ($F(1,165)=17.42$, $MSE=136.5$, $p<.001$, $\eta_p^2=.096$), but no main effect for either level ($F(1,165)=0.01$, $MSE=136.5$, $p=.911$, $\eta_p^2<.001$) or order ($F(1,165)=0.04$, $MSE=136.5$, $p=.841$, $\eta_p^2=.006$). Moreover, the three-way interaction was not significant ($F(1,165)=.18$, $MSE=136.5$, $p=.309$, $\eta_p^2=.014$). Post hoc comparisons showed that children who were administered the global block first scored significantly higher in the global block than in the local block (*p*=.003). In contrast, for children who were administered the local block first, the difference between the local and global block was not significant (*p*=.061), although accuracy was numerically higher for the local block. The same pattern was observed for reaction times (i.e., the difference between global and local blocks was larger for children who did the global block first). Thus, the results seem to suggest a global bias, but importantly the three-way interaction was not significant indicating that the group results were not confounded by a global bias or order effects.

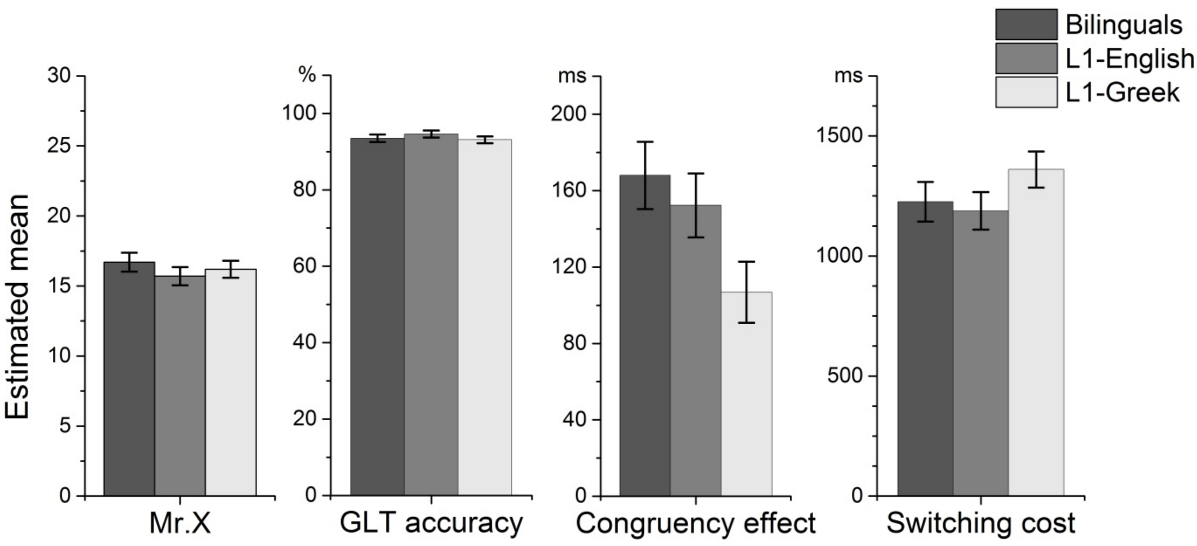


Figure 24. Estimated means for non-verbal EF measures.

Table 28 gives an overview of the bilingual and monolingual children's scores on the measures of executive function skills that included a verbal component. The analyses of the 2-back task was based on a subset of 172 children (bilinguals: 50, L1-English: 57 and L1-Greek: 65) due to technical problems that resulted in the loss of two data points (one in each control group). For the composite scores, the ANOVA with age as the sole covariate yielded no significant group effect ($F(2,168)=1.43$, $MSE=374.7$, $p=.243$, $\eta_p^2=.017$). The analysis was repeated with vocabulary as an additional covariate[32] to control for differences in language proficiency. The results showed no significant effect of group ($F(2,167)=1.18$, $MSE=375.9$, $p=.310$, $\eta_p^2=.014$). For *A*' scores, the ANCOVA with age yielded no significant group effect ($F(2,168)=1.80$, $MSE=102.7$, $p=.169$, $\eta_p^2=.021$). The addition of vocabulary as a covariate did not change the results ($F(2,167)=1.45$, $MSE=103.0$, $p=.238$, $\eta_p^2=.017$). Thus, there were no group differences for the measure of updating skills regardless of whether vocabulary was controlled for or not (see Figure 25). Next, children's scores on the digit backwards task in English were analysed to see whether the groups differed in verbal WM skills. The ANCOVA with age as covariate did not show a significant difference between groups ($F(1,105)=1.92$, $MSE=17.2$, $p=.169$, $\eta_p^2=.018$). However, the inclusion of English vocabulary scores as an additional covariate yielded a significant group effect ($F(1,104)=3.90$, $MSE=17.0$, $p=.050$, $\eta_p^2=.036$). The adjusted means show that the bilinguals scored higher than the English monolinguals (bilinguals: adjusted $M=18.2$, $SE=0.63$ vs. L1-English: adjusted $M=16.4$,

[32] Recall that the bilingual children could choose in which language they wanted to do the 2-back task. Hence, for the bilingual children who did the English version of the task (N=27) English vocabulary scores were used as a covariate in the analyses, while for the bilinguals who did the Greek version of the 2-back task, Greek vocabulary scores were used.

SE=0.58) on the digit backwards task in English. The same analyses were run for digit backwards scores in Greek. There was one missing data point in the monolingual group due to a child being absent on one of the testing days, hence, the analyses included 115 children (bilinguals: 50 and L1-Greek: 65). The ANCOVA with age as the only covariate did not produce a significant group effect $F(1,112)=0.58$, $MSE=18.5$, $p=.447$, $\eta_p^2=.005$). In contrast, adding Greek vocabulary scores as a covariate together with age resulted in a significant difference between the two groups ($F(1,111)=5.26$, $MSE=17.6$, $p=.024$, $\eta_p^2=.045$) with the bilinguals outperforming the Greek monolinguals (bilinguals: adjusted $M=18.9$, $SE=0.71$ vs. L1-Greek: adjusted $M=16.5$, $SE=0.60$). For the letter fluency task in English, the ANCOVA with age as the sole covariate showed no reliable group effect ($F(1,105)=0.19$, $MSE=53.4$, $p=.665$, , $\eta_p^2=.002$). Adding English vocabulary scores as a covariate in the analysis yielded a marginally significant group effect ($F(1,104)=3.46$, $MSE=49.4$, $p=.066$, $\eta_p^2=.032$), with the adjusted means indicating higher scores for the bilinguals than the English monolinguals (bilinguals: adjusted $M=30.0$, $SE=1.08$ and L1-English: adjusted $M=27.1$, $SE=0.99$). Thus, the results show that the bilinguals perform at the same level as their English monolingual peers on the LF task despite their lower level of proficiency in English. For LF scores in Greek, the ANCOVA with age as a covariate yielded a significant group effect ($F(1,113)=33.29$, $MSE=41.2$, $p<.001$, $\eta_p^2=.228$) with the monolinguals outperforming the bilinguals. The group effect in favour of the Greek monolinguals remained even after adding Greek vocabulary scores as an additional covariate to the analyses ($F(1,112)=4.44$, $MSE=35.8$, $p=.037$, $\eta_p^2=.038$). Although controlling for Greek vocabulary scores did not eliminate the difference between the two groups, the size of the effect was considerably reduced from $\eta_p^2=.228$ to $\eta_p^2=.038$. Figure 26 shows the estimated means from the two sets of analyses for scores on the digit backwards and the letter fluency tasks in English and Greek.

Table 28. *Scores for the verbal executive function measures.*

		Bilinguals	L1-English	L1-Greek
2-back composite score	*n*	50	57	65
	mean	48.1	51.7	48.5
	SD	19.9	20.2	18.8
	range	0–82.5	-12.5–80	-17.5–87.5
2-back *A'* score	*n*	50	57	65
	mean	81.2	83.7	81.1
	SD	10.2	9.9	10.4
	range	50–95.3	42.3–95	36.4–96.6
DB English	*n*	50	58	
	mean	18.0	16.6	
	SD	4.8	3.7	
	range	6–28	9–25	
DB Greek	*n*	50		65
	mean	17.4		17.7
	SD	4.4		4.8
	range	7–31		7–30
LF English	*n*	50	58	
	mean	29.1	27.9	
	SD	7.8	7.3	
	range	13–44	12–44	
LF Greek	*n*	50		66
	mean	19.3		28.4
	SD	6.9		7.6
	range	9–36		9–50

Note. DB=digit backwards; LF=letter fluency

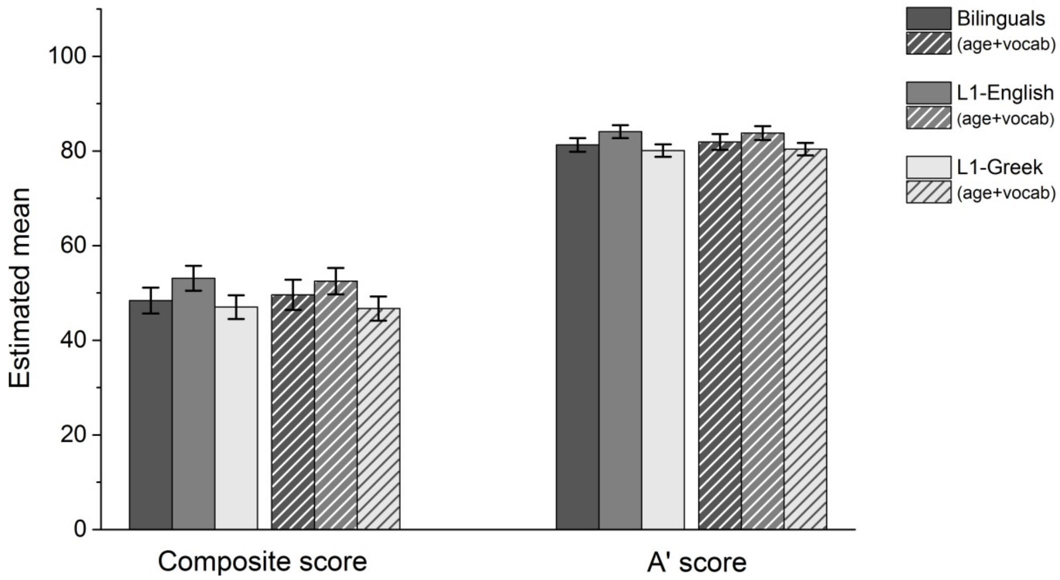


Figure 25. Estimated means for 2-back scores.

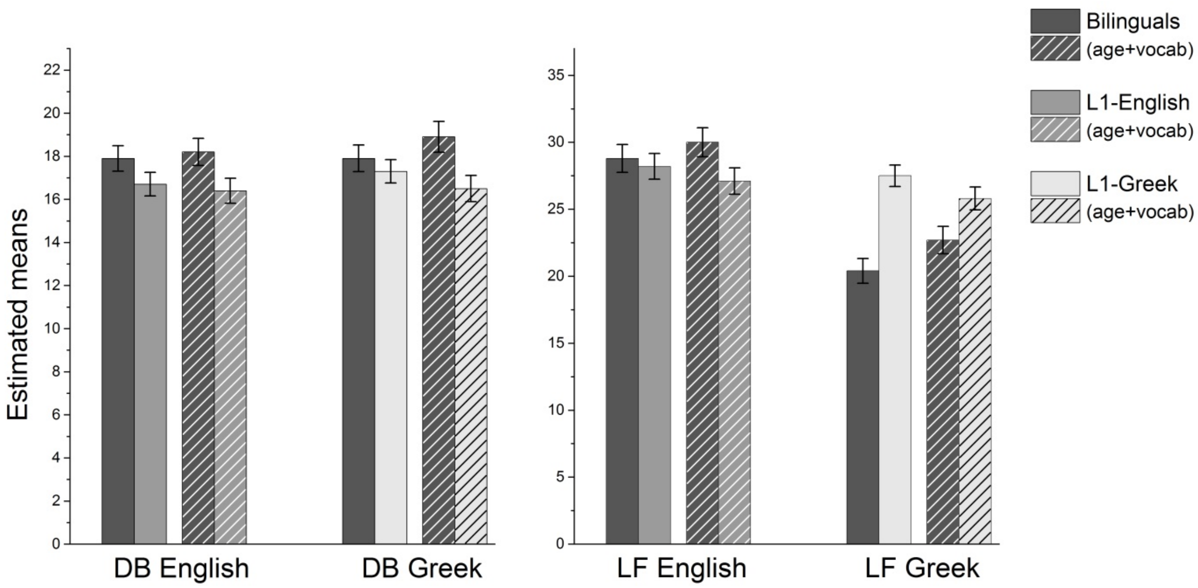


Figure 26. Estimated means for digit backwards and letter fluency in English and Greek.

3.6 Results: Group comparisons for measures of literacy skills

The monolingual and bilingual children's performances on the tasks tapping literacy skills were compared by means of ANCOVAs. One set of analyses controlled for differences in age only, and one included both age and vocabulary as covariates. The measures of interest were rapid serial naming (RAN), decoding, reading comprehension and the scores from the lexical decision task.

3.6.1 English

Table 29 gives an overview of the bilingual and English monolingual children's scores on the various measures of literacy skills in English. Children's performance on the rapid naming with digits task was measured in terms of the time (in seconds) it took them to read the two forms. Thus, lower scores indicate faster naming and therefore, better performance. The ANCOVA with age as the only covariate showed no significant group difference ($F(1,105)=1.44$, $MSE=51.4$, $p=.233$, $\eta_p^2=.014$). Adding English vocabulary as a covariate did not produce a reliable group effect either ($F(1,104)=3.23$, $MSE=50.71$, $p=.075$, $\eta_p^2=.030$), although there was a tendency for the bilinguals to be faster on the rapid naming task than the L1-English (bilinguals: adjusted $M=30.5$, $SE=1.1$ vs. L1-English: adjusted $M=33.5$, $SE=1.0$).The same analyses were run on children's scores on the Single Word Reading Test (SWRT). The ANCOVA with age as a covariate yielded no significant difference between groups ($F(1,105)=0.14$, $MSE= 36.5$, $p=.706$, $\eta_p^2=.001$). Adding English vocabulary scores as a covariate in the analysis did not change the results ($F(1,104)=3.22$, $MSE=30.7$, $p=.076$, $\eta_p^2=.030$), although the adjusted means suggest that the bilinguals tended to score slightly higher on English decoding than the L1-English (bilinguals: adjusted $M=49.6$, $SE=0.85$ vs. L1-English: adjusted $M=47.4$, $SE=0.78$). Thus, the results show that the bilinguals perform at an equal level as their monolingual peers on single word reading in English despite their smaller vocabularies. For reading comprehension, the ANCOVA with age as the sole covariate produced a significant group effect in favour of the L1-English ($F(1,105)=4.69$, $MSE=48.8$, $p=.033$, $\eta_p^2=.043$). However, the group effect disappeared after adding English vocabulary scores as a covariate in the analysis $F(1,104)=0.74$, $MSE=34.8$, $p=.390$, $\eta_p^2=.007$). Hence, the bilinguals show similar performance on reading comprehension in English as their monolingual peers once differences in vocabulary are accounted for. The estimated group means for rapid naming, decoding (SWRT) and reading comprehension (YARC) in English are shown in Figure 27. Turning to the lexical decision task, for overall accuracy the ANCOVA with age as a covariate yielded no significant group effect ($F(1,105)=2.47$, $MSE=46.5$, $p=.119$, $\eta_p^2=.023$). The inclusion of vocabulary as an additional covariate did not change the results[33] ($F(1,104)=0.33$, $p=.570$, $\eta_p^2=.003$). For *A'* scores on the LDT, the ANCOVA with age as a covariate produced no reliable group effect ($F(1,105)=2.07$, $MSE=21.5$, $p=.153$, $\eta_p^2=.019$). Adding vocabulary scores as a covariate yielded no group effect either ($F(1,104)=0.31$, $MSE=18.7$, $p=.577$,

[33] The inclusion of stimulus type (words vs. pseudowords) as within-subjects factor in the model did not produce a significant interaction between stimulus type and group ($F(1,105)=0.01$, $MSE=63.8$, $p=.744$, $\eta_p^2=.001$). Thus, the results for words and pseudowords were the same in that both showed no differences between groups.

η_p^2=.003). The same analyses were run with the size of the lexicality effect as the dependent variable. The ANCOVA with age as covariate showed no reliable group effect (F(1,105)=0.18, MSE=534,978, p=.671, η_p^2=.002). Including vocabulary scores as an additional covariate did not yield a significant group difference either (F(1,105)=0.19, MSE=540,040, p=.666, η_p^2=.002). Taken together, the results for the LDT show that despite their smaller vocabularies, the bilinguals perform at an equal level as the L1-English (see Figure 28).

Table 29. *Scores for literacy measures in English.*

		Bilinguals	**L1-English**
RAN (in seconds)	*n*	50	58
	mean	30.8	33.0
	SD	7.8	6.9
	range	18.5–60.5	20.5–57
SWRT raw score max. 60	*n*	50	58
	mean	48.5	48.3
	SD	7.9	4.8
	range	19–58	37–56
YARC ability score max. 85	*n*	50	58
	mean	63.5	65.9
	SD	8.8	5.5
	range	39–81	51–80
LDT accuracy (%)	*n*	50	58
	mean	89.7	91.5
	SD	7.7	6.1
	range	65.6–100	67–100
LDT *A'* score	*n*	50	58
	mean	93.8	94.9
	SD	5.0	4.3
	range	79.8–100	74.4–100
LDT lexicality effect (in milliseconds)	*n*	50	58
	median	588	696
	SD	845	650
	range	49–5624	-21–2980

Note. RAN = rapid automatized naming; SWRT = Single Word Reading Test; YARC = York Assessment of Reading Comprehension; LDT = lexical decision task

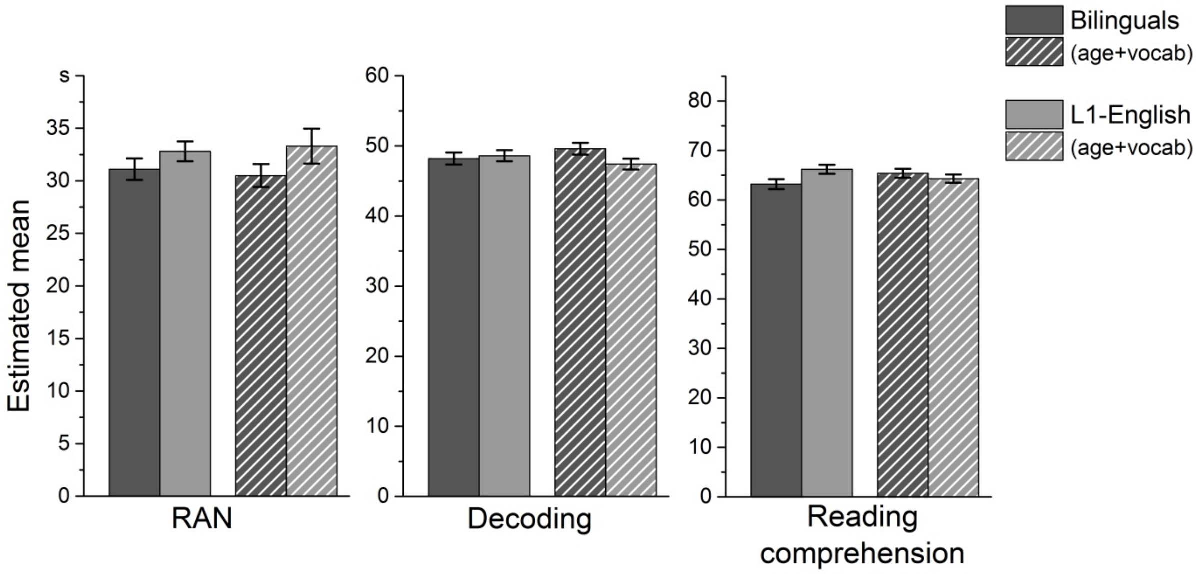


Figure 27. Estimated means for RAN, decoding and reading comprehension in English.

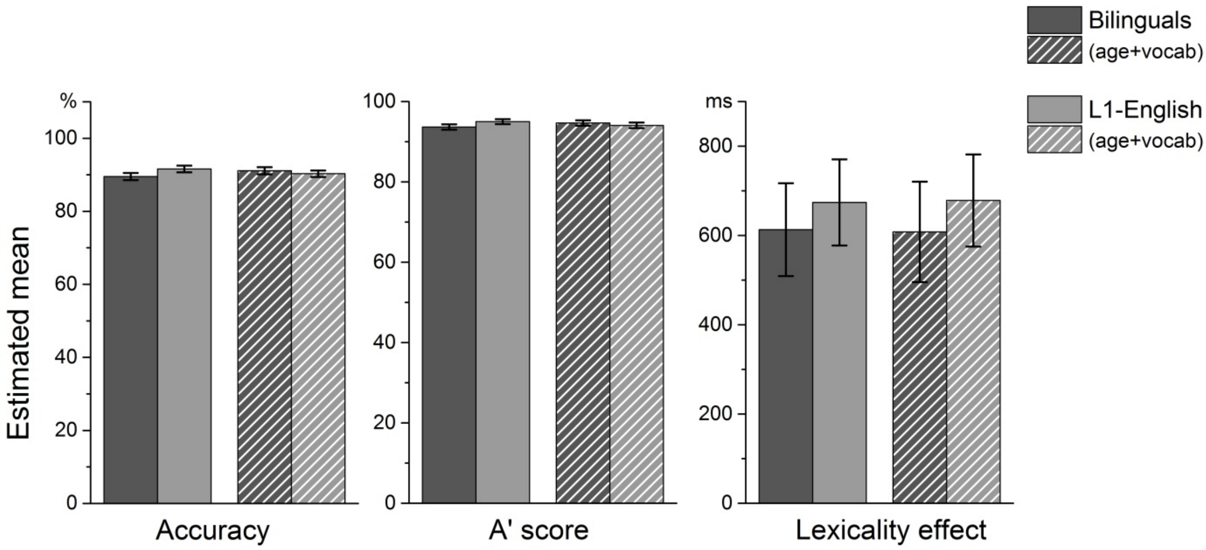


Figure 28. Estimated means for LDT in English.

3.6.2 Greek

The scores of the bilinguals and the monolinguals on the Greek literacy measures are given in Table 30. For rapid naming of digits in Greek, the ANCOVA with age as the sole covariate showed that the Greek monolinguals were significantly faster than the bilinguals ($F(1,113)=10.78$, $MSE=182.9$, $p=.001$, $\eta_p^2=.087$). However, the group difference disappeared after including Greek vocabulary scores as a covariate ($F(1,112)=0.96$, $MSE=137.8$, $p=.330$, $\eta_p^2=.008$). Thus, the bilinguals did not differ in rapid naming of digits from their Greek monolingual peers when differences in age and vocabulary were accounted for. The group comparison for overall accuracy on the decoding measure using age as a covariate resulted in a significant group effect ($F(1,113)=21.2$, $MSE=247.8$, $p<.001$, $\eta_p^2=.158$), with the L1-Greek outperforming the bilinguals. However, the group difference disappeared after adding Greek vocabulary scores as a covariate[34] ($F(1,112)=1.82$, $MSE=221.2$, $p=.180$, $\eta_p^2=.016$). The bilinguals performed on a par with their monolingual peers on decoding in the minority language Greek once differences in vocabulary scores are accounted for. The estimated group means for rapid naming and decoding in Greek are shown in Figure 29. The analyses of the reading comprehension tasks in Greek are based on a subset of children. This is due to some of the bilingual children having insufficient literacy skills in Greek to read connected text and to carry out the reading comprehension subtests. More specifically, six bilingual children could not do any of the reading comprehension subtests and another 18 bilinguals were only administered the sentence matching task, but not the passage comprehension subtest. One of the L1-Greek children was absent on one of the testing days and thus, could not be administered the two reading comprehension tasks. Hence, the analyses of reading comprehension composite scores (sentence matching and passage comprehension) included 109 children (bilinguals: 44 and L1-Greek: 65). Note that the composite score for the 18 children who were not administered the passages is based on the sentence matching task alone which consisted of only four test items. Thus, separate analyses were run for the passage comprehension subtest which included 97 children in total (bilinguals: 32 and L1-Greek: 65). For the composite scores for reading comprehension, the ANCOVA with age as the sole covariate yielded a significant group effect ($F(1,106)=18.57$, $MSE=514.6$, $p<.001$, $\eta_p^2=.149$) with the L1-Greek outperforming the bilinguals. However, the group difference disappeared after adding Greek vocabulary scores as a covariate in the analysis ($F(1,105)=0.60$, $MSE=337.6$, $p=.442$, $\eta_p^2=.006$). Considering only the passage comprehension subtest, the ANCOVA with age as a covariate yielded no reliable group effect ($F(1,94)=3.19$, $MSE=338.1$, $p=.077$, $\eta_p^2=.033$) although there was a trend for the L1-Greek to outperform the bilinguals (L1-Greek: adjusted $M=71.2$, $SE=2.3$ vs. bilinguals: adjusted $M=64.1$, $SE=3.3$). Adding vocabulary scores as a covariate in the ANCOVA did not produce a significant group effect either ($F(1,93)=2.52$, $MSE=252.7$, $p=.116$, $\eta_p^2=.026$), but interestingly the adjusted mean after controlling for vocabulary was higher for the bilinguals

[34] Recall that the Greek decoding measure included both real words and pseudowords. However, additional analyses that included stimulus type (words vs. pseudowords) as a within-subjects factor showed no significant interaction between group and stimulus type ($F(1,113)=0.96$, $MSE=69.2$, $p=.329$, $\eta_p^2=.008$). Thus, the results for the group comparison were the same for words and pseudowords.

than for the monolinguals[35] (bilinguals: adjusted *M*=73.4, *SE*=3.3 vs. L1-Greek: adjusted *M*=66.7, *SE*=2.1). Taken together, the results suggest that the bilingual children's lower performance on reading comprehension in the minority language Greek is largely attributable to their smaller vocabularies. Figure 30 shows the estimated group means for the two sets of analyses of composite scores and scores on the passage comprehension subtest. The analyses of the LDT in Greek included 112 children (bilinguals: 47 and L1-Greek: 65). Three of the bilingual children could not complete the task because it was too difficult for them, and one monolingual child was absent on the particular testing day. Performance on the 20 illegal words was used an inclusion criteria with a cut-off point of <60%. None of the children scored below 60% on the illegal words thus, all 112 children were included in the analyses. For overall accuracy, the ANCOVA with age as covariate produced a significant group effect with the L1-Greek scoring higher than the bilinguals ($F(1,109)=42.2$, $MSE=52.1$, $p<.001$, $\eta_p^2=.279$). The inclusion of vocabulary as an additional covariate removed the group effect[36] ($F(1,108)=1.07$, $MSE=33.3$, $p=.303$, $\eta_p^2=.010$). With regard to *A*' scores, the ANCOVA with age as covariate produced a significant group effect with the L1-Greek outperforming the bilinguals ($F(1,109)=39.39$, $MSE=34.6$, $p<.001$, $\eta_p^2=.265$). However, the group effect disappeared after adding Greek vocabulary scores as an additional covariate in the analysis ($F(1,108)=0.96$, $MSE=22.9$, $p=.330$, $\eta_p^2=.009$). Thus, the bilingual children's lower accuracy on the lexical decision task in Greek is due to their smaller vocabularies. The analyses were repeated with the size of the lexicality effect as the dependent variable. The ANCOVA with age as covariate yielded no reliable group effect ($F(1,109)=0.53$, $MSE=548{,}498$, $p=.468$, $\eta_p^2=.005$). The ANCOVA with Greek vocabulary as an additional covariate did not reveal a significant group difference either ($F(1,108)=0.26$, $MSE=540{,}120$, $p=.613$, $\eta_p^2=.002$). The bilingual children were equally efficient in distinguishing real words from pseudowords than their monolingual peers. The estimated group means for the measures from the Greek LDT are depicted in Figure 31.

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[35] Note that this particular bilingual subgroup did not differ from the monolinguals on the measure of English reading comprehension either ($F(1,87)=2.37$, $MSE=44.4$, $p=.127$, $\eta_p^2=.027$). Moreover, the inclusion of vocabulary as a covariate yielded a significant group effect with the bilinguals outperforming the English monolinguals on English reading comprehension ($F(1,86)=4.85$, $MSE=29.9$, $p=.030$, $\eta_p^2=.053$).

[36] The analyses were repeated with stimulus type (words vs. pseudowords) as within-subjects factor to ascertain that the results were not affected by stimulus type. The results showed no interaction between group and stimulus type ($F(1,109)=0.01$, $MSE=107.9$, $p=.960$, $\eta_p^2<.001$) confirming that the results for words and pseudowords were the same.

Table 30. *Scores for literacy measures in Greek.*

		Bilinguals	**L1-Greek**
RAN (in seconds)	*n*	50	66
	mean	41.1	29.9
	SD	20.9	5.8
	range	23–150	20.5–52
Decoding (%)	*n*	50	66
	mean	71.7	89.7
	SD	24.5	8.6
	range	3.9–98.7	66.2–100
RC composite (%)	*n*	44	65
	mean	47.7	72.1
	SD	32.9	21.8
	range	4–96	8–100
RC passage only (%)	*n*	32	65
	mean	61.0	72.8
	SD	28.2	21.5
	range	14.3–95.2	4.76–100
LDT accuracy (%)	*n*	47	65
	mean	80.6	91.4
	SD	10.5	5.8
	range	55.5–100	65.5–100
LDT *A'* score	*n*	47	65
	mean	86.7	95.1
	SD	8.9	3.7
	range	59.6–100	78.4–99.6
LDT lexicality effect (in milliseconds)	*n*	47	65
	median	1132	962
	SD	946.9	569.2
	range	-755–4350	87–2391.5

Note. RAN = rapid automatized naming; RC = reading comprehension; LDT = lexical decision task

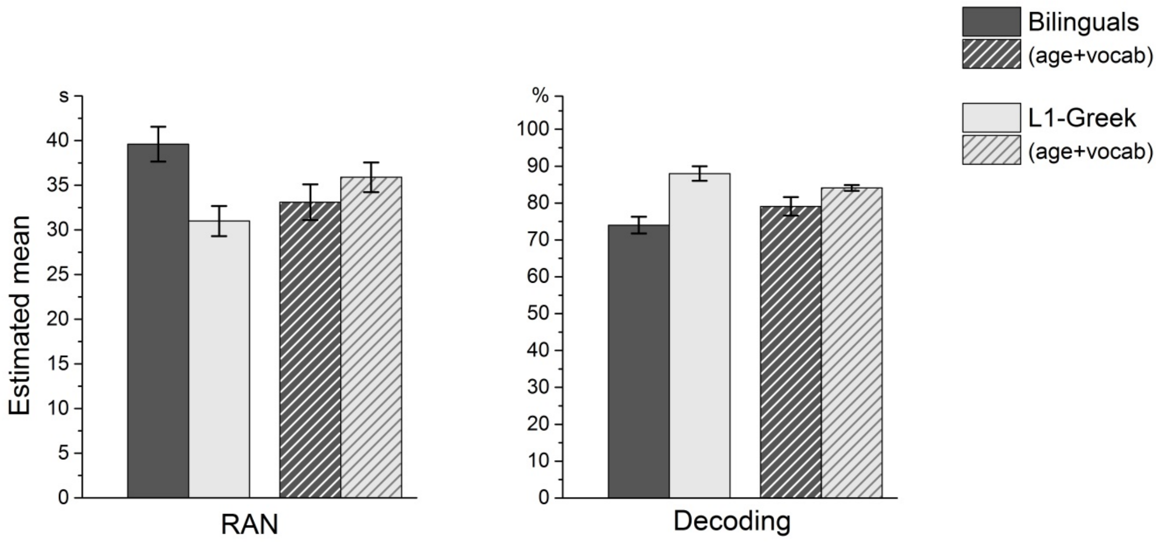

Figure 29. Estimated means for RAN and decoding in Greek.

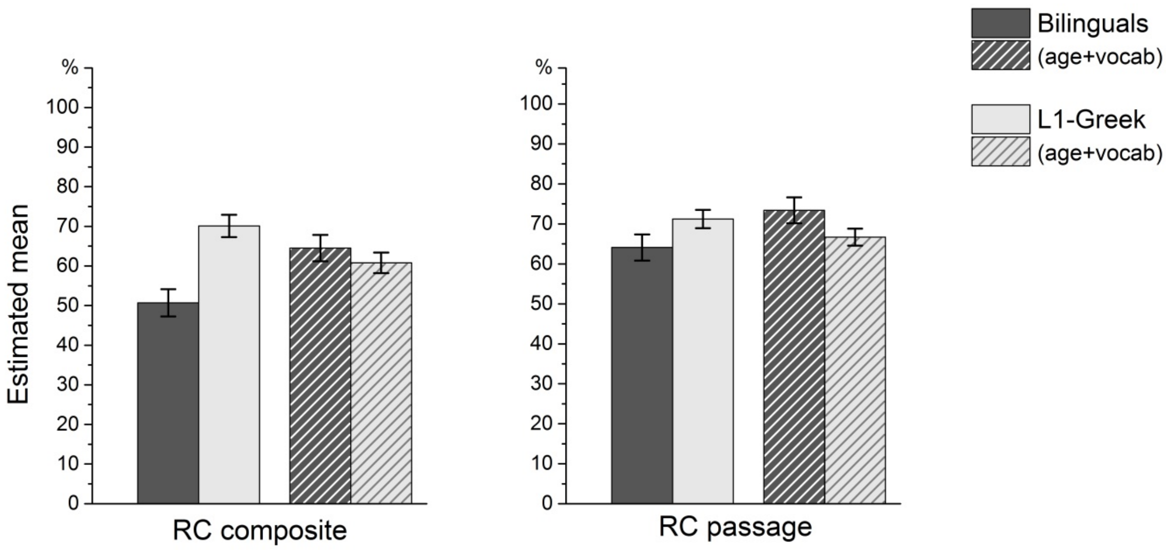

Figure 30. Estimated means for reading comprehension in Greek.

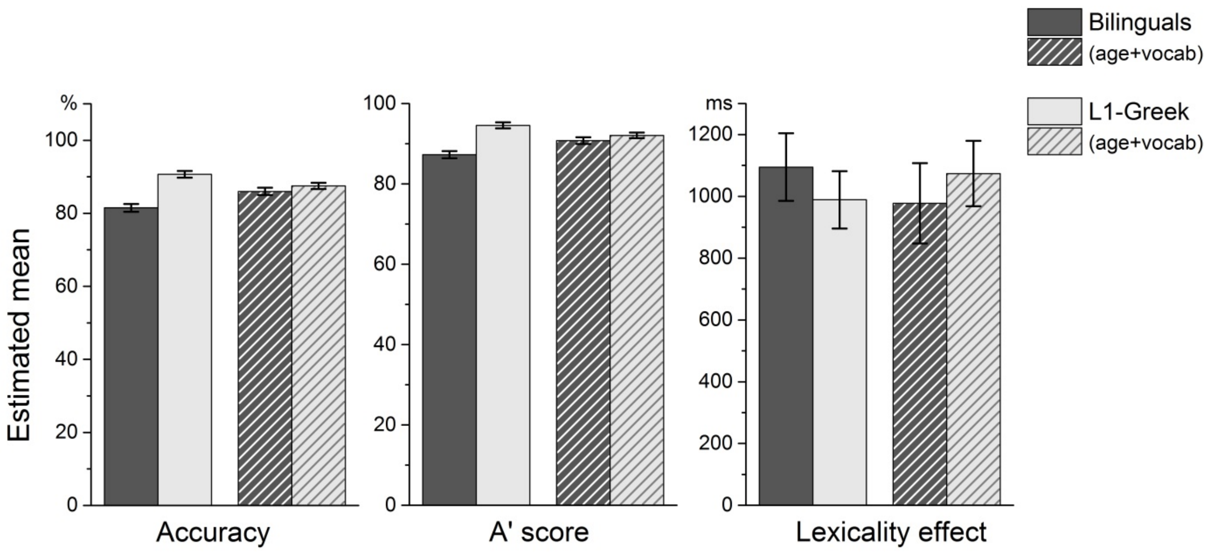

Figure 31. Estimated means for LDT in Greek.

3.7 Results: Comparisons between English and Greek measures for the bilinguals

The interaction between bilingual profile effects and language status (minority vs. majority language) was further examined by comparing the bilingual children's performances on the various measures across languages by means of paired-samples *t*-tests. The results from the analyses are summarized in Figure 32 which shows the effect sizes (Cohen's *d*) associated with the difference scores for English and Greek for the various measures (the specific means, *SD*s, *t* statistics and *p* values are attached in Appendix Q). Syntactic complexity and length of the narratives, as well as verbal working memory did not differ across languages. For all other measures there were significant differences between languages with the children exhibiting superior performance in English (see Appendix Q). The smallest differences between English and Greek scores were observed for word decoding, the two types of comprehension questions, as well as for grammaticality and verb diversity from the narrative microstructure scores (all *d*s between 0.3 and 0.4). For the bilingual children who were administered both the sentence matching and the passage comprehension subtests of the Greek reading comprehension measure (RC-passage), the difference between English and Greek performance was associated with a moderate effect size (*d*=0.49). In contrast, the comparison that included children who could only be administered the sentence matching task (RC-composite) yielded a large effect size of *d*=0.82. Rapid automatized naming and expressive vocabulary scores were associated with a medium-sized effect[37] (*d*=0.52 for RAN and *d*=0.56 for vocabulary). Slightly larger effect sizes

[37] Note that the crosslinguistic comparison for performance on the rapid naming task is not as straightforward as the names of the digit stimuli in Greek were longer (i.e., contained more syllables) than the digit names in English.

were observed for the size of the lexicality effect in the LDT and for the grammaticality and structure scores from the SRT (*d*s between 0.63 and 0.69). Accuracy and *A*' scores for the LDT yielded effect sizes of 0.78 and 0.76, respectively. Overall accuracy on the SRT showed a very large effect size of nearly one standard deviation (*d*=0.95), and the effect size associated with performance on the letter fluency task exceeded one standard deviation (*d*=1.24).

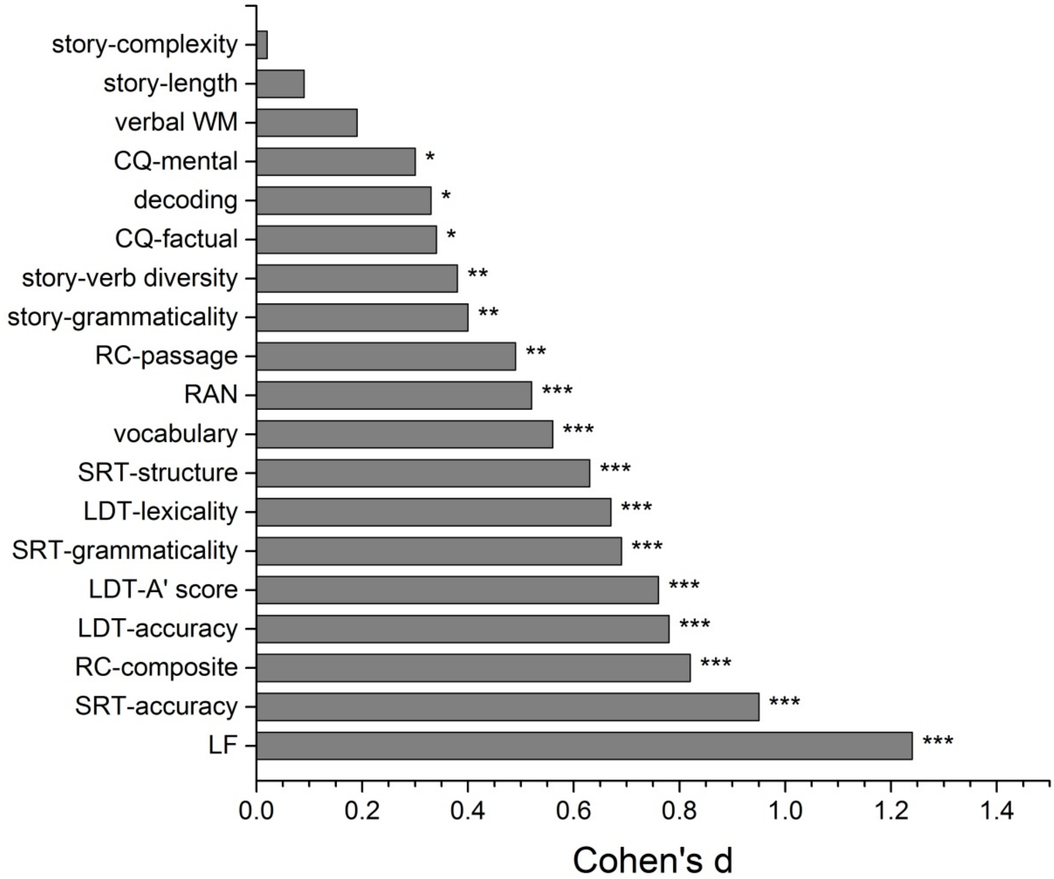

Figure 32. Effect sizes (Cohen's *d*) for cross-language comparisons.

In addition to the cross-language comparisons, the correlations between English and Greek scores on the various measures were examined. The results are summarized in Figure 33. Results showed a significant negative correlation for scores on the measures of expressive vocabulary (*r*(50)=-.316, *p*=.025). There was also a tendency for the three SRT scores and for the grammaticality measure of the narratives to be negatively correlated across languages, although the associations did not reach significance. In contrast, there was a strong positive correlation for scores on the digit backwards task (verbal WM) which was also highly significant (*r*(50)=.778, *p*<.001). Moreover, the results showed strong positive cross-language correlations for decoding skills (*r*(50)=.569, *p*<.001) and for story length (*r*(50)=.587, *p*<.001). Letter fluency scores and syntactic complexity of the narratives also showed significant positive relationships across languages (LF: *r*(50)=.428, *p*=.002; story-complexity: *r*(50)=.396, *p*=.004).

Finally, the measure of verb diversity from the narratives and rapid automatized naming both showed small positive correlations (verb diversity: *r*(50)=.325, *p*=.021 and RAN: (*r*(50)=.316, *p*=.026).

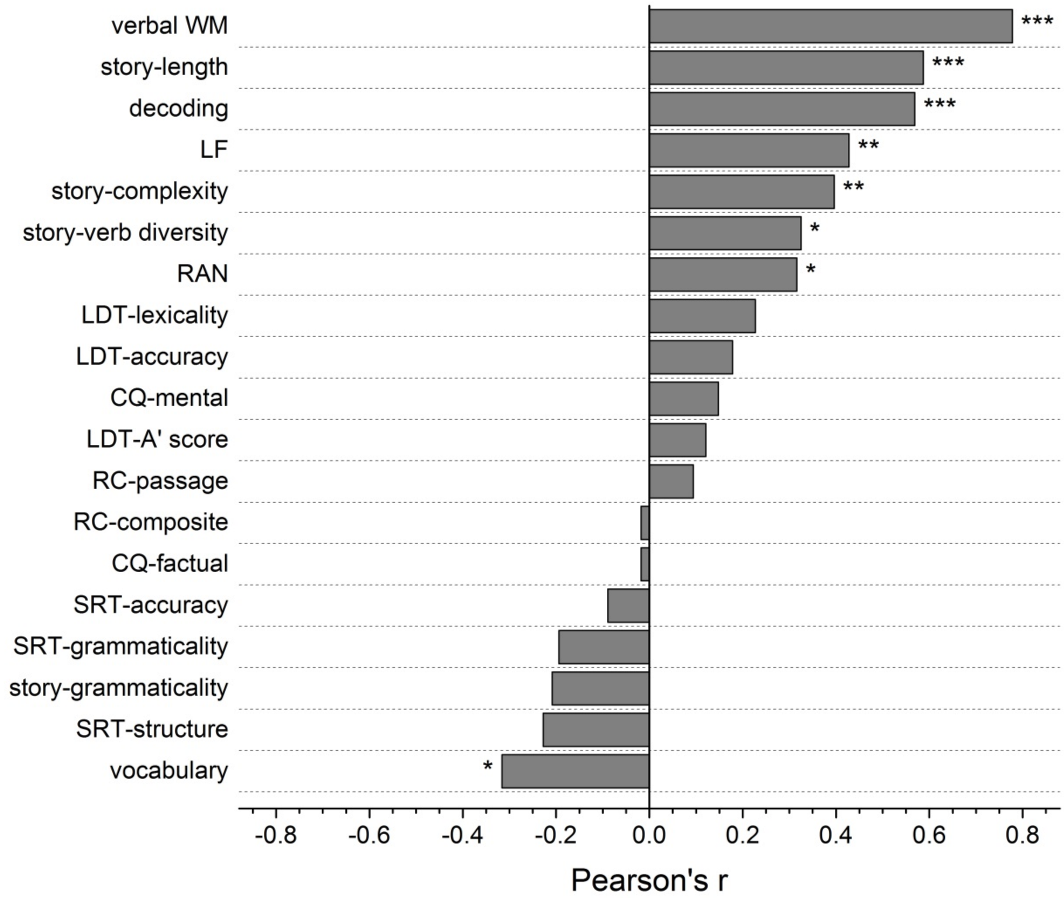

Figure 33. Cross-language correlations (Pearson's r) for the various measures.

3.8 Discussion

The aim of this chapter was to give an overview of the bilingual children's strengths and weaknesses across a range of measures tapping oral language abilities, literacy skills as well as EF skills. To this end, a series of ANCOVAs was performed to compare the bilingual children's performances to two monolingual control groups in the respective languages, English and Greek. The first research question sought to establish whether there were any group differences in non-verbal IQ and expressive vocabulary scores. The second research question asked whether the bilinguals differ from their monolingual peers in oral language skills in English and Greek, after controlling for differences in vocabulary. The third research question was concerned with possible group differences on verbal and non-verbal measures of executive function skills, controlling again for differences in vocabulary in the case of EF measures with a verbal component. The fourth research question examined whether the bilingual children differed from their monolingual peers in literacy skills in English and Greek, when differences in vocabulary are accounted for. Finally, the fifth research question focused on the comparison of the bilingual children's performance in the majority and minority language, English and Greek. The results for each of the five questions are discussed in the following sections.

Non-verbal IQ & vocabulary

The results for the Raven's showed that the three groups were well matched on non-verbal IQ. This corroborates previous research that has shown no differences between monolinguals and bilinguals in terms of general non-verbal abilities (e.g., Bialystok & Shapero, 2005; Engel de Abreu, 2011). In contrast, studies have consistently shown lower vocabulary skills by bilinguals compared to monolinguals (Bialystok et al., 2010; Oller et al., 2007). In line with this, the bilinguals in the current study had significantly lower vocabulary scores in both languages compared to their monolingual peers, although the effect was twice as large for Greek than for English (see Cobo-Lewis, Pearson, Eilers & Umbel, 2002b, for similar results). Finally, it was anticipated that the bilingual children would score lower on vocabulary in the minority language Greek than the majority language English. The comparison of the vocabulary scores across languages showed that this was indeed the case.

Oral language skills

Sentence repetition: Overall accuracy on the SRT was expected to be lower in the bilinguals compared to the monolinguals due to the lexical component of the task. The results showed that the bilinguals were significantly less accurate than their monolingual peers in both languages, with the effect being twice as large in the minority language Greek. This is in line with several studies reporting lower performance of bilinguals on sentence imitation tasks (e.g., Babayiğit, 2014; Droop & Verhoeven, 2003). Notably, the group difference disappeared in both languages when vocabulary was included as a covariate in the analyses, which corroborates previous findings by Komeili and Marshall (2013). The same pattern emerged for the other two measures from the SRT, namely the grammaticality and the structure scores. In both English and Greek, the monolinguals scored significantly higher than the bilinguals, but this was largely attributable to the monolinguals superior vocabulary skills, since there was no difference between groups once lexical abilities were accounted for. While this pattern of results was anticipated for the minority language Greek, no group differences were predicted for the stronger language English, given that these alternative scoring methods place less emphasis on lexical skills. However, the results suggest that the ability to produce a grammatical response and correctly use the target structures in the context of a sentence repetition task is closely tied to lexical skills in bilinguals. This is in line with the strong relationship between lexical and grammatical development observed in younger children (e.g., Marchman, Martínez-Sussmann & Dale, 2004).

Listening comprehension: With regard to the measure of listening comprehension, there were no group differences for either question type in English, regardless of whether vocabulary was included as a covariate or not. In contrast, the results for Greek showed the same pattern as the SRT measures, namely significantly higher scores on part of the monolinguals, but no significant group effect when differences in vocabulary are taken into account. Although the results for English were unexpected, other studies have also failed to find group differences between monolinguals and bilinguals on measures of listening comprehension (e.g., Bowyer-Crane et al., 2017; Westman et al., 2008). Note that overall, scores were very high in both groups and languages (>84%) suggesting that the task was relatively easy for the children. Nevertheless, the findings for both languages are in line with results from Babayigit (2014) who found that monolingual-bilingual differences were much more pronounced in vocabulary compared to listening comprehension.

Asymmetries across tasks and languages: Inspection of the effect sizes for the various comparisons revealed that the group differences were most marked for vocabulary, followed by SRT scores and listening comprehension which in the case of English did not show any group differences. Moreover, on all oral language measures, the effect size was roughly twice as large in the minority language Greek compared to English. Taken together, the findings for the measures of oral language skills suggest that the results for monolingual-bilingual differences are heavily dependent on the measure used.

Executive function skills

Non-verbal EF measures: Studies that have found a bilingual advantage in EF skills have typically used non-verbal tasks that involve some kind of conflicting information which needs to be inhibited (e.g., Bialystok & Barac, 2012; Calvo & Bialystok, 2014). Thus, the prediction was for the bilinguals to outperform the monolinguals on the measures of inhibitory control and task switching abilities assessed within a Global-Local task. This prediction was not borne out in the present sample. In fact the results showed that the size of the congruency effect was significantly smaller in the Greek monolinguals compared to the bilinguals, while no group differences emerged in terms of the magnitude of the switching cost. This is in contrast to studies that report superior performance on part of the bilinguals on Global-Local tasks (e.g., Bialystok, 2010; Christoffels, de Haan, Steenbergen, van den Wildenberg & Colzato, 2015; Prior & MacWhinney, 2010). However, the finding that the Greek monolinguals outperformed the bilinguals on the measure of inhibition supports the view that all speakers have alternative, non-linguistic ways to improve their executive function skills (Valian, 2015). Both the bilinguals and the English monolinguals were residing in the UK and attended English mainstream primary schools (except the thirteen bilinguals that were enrolled in the Greek school). Thus, it is possible that that some aspect of the educational system in Greece or habits induced by the Greek culture indirectly led to the superior inhibitory control in the Greek monolinguals in the current sample. Another reason for the conflicting findings across studies might be differences in task design. More specifically, in the present study, the switching cost was calculated as the difference between incongruent trials in the single blocks and incongruent trials in the mixed block, which were, however, always switch trials. In other studies, the mixed block typically contains both switch and no-switch trials, so that the switching cost can be calculated by comparing no-switch trials in the mixed block with trials in the single blocks (which are always no-switch trials), or by comparing switch and no-switch trials within the mixed block (e.g., Prior & MacWhinney, 2010). Moreover, the version of the task used in the present study included four stimuli (i.e., shapes) to which the children had to attend simultaneously, while other studies with child participants tend to use only two different stimuli (e.g., Christoffels et al., 2015). Thus, the cognitive demands in the current version of the task might have been too high to reliably measure the children's inhibition and switching skills. On the other hand, the present findings are in line with the mounting evidence that there is no bilingual advantage in inhibitory control or switching abilities (e.g., Bruin, Treccani & Sala, 2015; Duñabeitia et al., 2014; Gathercole et al., 2014; Paap et al., 2015). Future investigations are needed that take into account details of the task design to ensure that the task is age appropriate and that the measures are comparable to those used in previous studies. For the measure of non-verbal working memory, the results did not reveal any group effects either, which is at odds with previous studies reporting better non-verbal WM skills in bilinguals compared to monolinguals (e.g., Blom et al., 2014; Morales et al., 2013). Both Blom et al. (2014) and Morales et al. (2013) used tasks that were very similar to the Mr. X task administered in the current study, which makes it unlikely that the different findings are due to task-specifics. Moreover, in line with the present results, Blom et al. (2017) reported no differences between monolinguals and bilinguals on non-verbal WM, although the same task was used as in the study by Blom et al. (2014), which did show significant group effects. It is unclear how the conflicting findings can be reconciled. A currently prominent idea in the field is that the apparent benefits in inhibitory control, switching and WM observed in bilinguals are in fact due to a bilingual advantage in selective attention which would explain the mixed findings in the literature (Chung-Fat-Yim et al., 2017). Alternatively, it has been suggested that variables such as balanced proficiency across the two languages, bilingual education or frequency of code-switching drive the bilingual advantage rather than bilingualism per se (Bialystok & Barac, 2012; Hofweber et al., 2016). Thus, another explanation for the lack of a bilingual advantage in the non-verbal EF tasks is that bilingualism was treated as a binary variable without considering more fine-grained nuances of bilingualism, such as the children's proficiency levels in the two languages or their levels of biliteracy. In a similar vein, it has been argued that cognitive benefits associated with bilingualism only emerge when a certain level of bilingual proficiency has been attained (e.g., Bialystok & Barac, 2012; Carlson & Meltzoff, 2008; Crivello et al., 2016; Poarch & van Hell, 2012). Thus, it is possible that some of the bilingual children in the current sample had insufficient levels of bilingual proficiency to promote the acclaimed advantages in EF, so that differences at the group level were obscured by individual differences in bilingual proficiency.

Verbal EF measures: With regard to the EF tasks with a verbal component, the expectation was for bilinguals to outperform the monolinguals only when vocabulary scores are controlled for. The results showed that performance on the 2-back task did not differ across groups, regardless of whether vocabulary was included as a covariate or not. In a recent study, Marinis et al. (under review) found that performance on the 2-back task in bilinguals was predicted by amount of exposure to bilingual education. More specifically, children who received roughly equal amounts of formal instruction in both languages (balanced bilingual education) outperformed children who were instructed in predominantly one language. The bilingual children in the current sample showed large variations in terms of amount of schooling in the two languages, with the majority having received formal instruction primarily in English. Hence, it is possible that the lack of a bilingualism effect is due to the heterogeneity within the bilingual group in terms of the amount of exposure to the two languages. For verbal WM, the analyses without vocabulary as a covariate showed equal performance of the monolinguals and the bilinguals in both English and Greek. No group difference emerged for the letter fluency task in English either, which goes against the prediction that the monolinguals would score higher than the bilinguals on this task. When differences in vocabulary were accounted for, there was a strong tendency for the bilinguals to score higher than the monolinguals on the letter fluency task in English, as indicated by the marginally significant group effect. For verbal WM in both languages, the inclusion of vocabulary as a covariate yielded a significant group effect with the bilinguals outperforming the monolinguals. The results for verbal WM are in line with recent findings by Blom et al. (2014) who found superior performance on WM measures by bilinguals once differences in vocabulary were controlled for. The findings for the letter fluency task in English align well with studies by Bialystok et al. (2008) and Luo et al. (2010) who reported the same pattern in a sample of young adults, i.e., superior performance on part of the bilinguals when vocabulary is included as a covariate in the analyses, but equal performance without vocabulary as a covariate. Thus, the current findings are consistent with the idea that certain EF skills are enhanced by bilingualism, and that the enhanced EF skills and lower vocabularies in this group cancel each other out resulting in equal performance on hybrid tasks, such as letter fluency (Bialystok et al., 2008). In contrast, the Greek monolinguals outperformed the bilinguals on the LF task in Greek. Adding Greek vocabulary scores as a covariate in the analysis led to a considerable reduction of the group effect, but the difference remained significant. The LF task has a much stronger verbal component than the digits backwards task which suggests that the gap in lexical skills in the minority language Greek was too big for the bilinguals to be compensated for by other skills.

Literacy skills

Turning to the literacy measures, it was predicted that the bilinguals would show equal performance than the monolinguals on rapid naming and single word decoding, while performance on lexical decision and reading comprehension was expected to be lower in the bilinguals compared to the monolinguals.

English: For RAN in English, the results showed that the bilinguals performed at the same level as the English monolinguals, despite their lower vocabulary skills. This is consistent with findings by Geva et al. (2000) who reported no group differences between monolinguals and bilinguals on rapid naming at the end of Grade 2, despite superior performance on part of the monolinguals at the end of Grade 1. Similarly, there was no difference between the groups on the English decoding measure which is in accordance with a large number of studies (e.g., Babayiğit, 2014; Jongejan et al., 2007; Melby-Lervåg & Lervåg, 2014; Oller et al., 2007). The analyses in the present study further revealed that controlling for differences in English vocabulary resulted in a tendency for the bilinguals to outperform their monolingual peers on both RAN and the decoding measure. Note that the digit backwards task (i.e., verbal WM) and rapid serial naming of digits both implicate executive function abilities, and are often subsumed under phonological processing skills, which in turn, are strongly related to basic reading skills. Interestingly, there are a number of studies that found a bilingual advantage in phonological awareness at the beginning of formal instruction (e.g., Kuo & Anderson, 2010), and there is considerable evidence that phonological skills are transferable across languages (Durgunoğlu, 2002; Melby-Lervåg & Lervåg, 2011). Although rapid serial naming and verbal working memory are not measures of phonological awareness per se, it can be argued that phonological processing in general is an area of strength in bilinguals. Hence, it is possible that bilinguals are able to compensate for their lower vocabulary skills by their enhanced phonological processing skills and/or superior EF skills which results in equal performance compared to monolinguals on measures of verbal WM, rapid naming and word decoding. The current results obtained for the majority language English support this hypothesis. In contrast, the bilingual children in the present study scored lower on reading comprehension in English than their monolingual peers which is in line with a large body of research (e.g., Babayiğit, 2014; Bellocchi et al., 2017; Melby-Lervåg & Lervåg, 2014; Netten, Droop & Verhoeven, 2011). The analyses further showed that this difference was mainly attributable to the bilingual children’s lower lexical skills, as the group effect disappeared after controlling for differences in vocabulary. This is not surprising since linguistic comprehension (which subsumes vocabulary) is one of the two main components of reading comprehension, and given the fact that its contribution to reading performance increases throughout development (Hoover & Gough, 1990). Thus, the present findings support the view that the bilingual children's lower performance on measures of reading comprehension compared to monolinguals can, to a large extent, be explained by their lower vocabulary skills (Babayiğit, 2015; Burgoyne et al., 2011; Cobo-Lewis et al., 2002a). In contrast to the predictions, the bilingual children's performance on the lexical decision task in English was not different from monolinguals (both accuracy and lexicality effect). Moreover, using vocabulary as a covariate in the analyses did not change the results. This seems surprising given that vocabulary knowledge is clearly paramount for lexical decision. One possible explanation is that lexical decision implicates primarily receptive language skills. Studies have shown that receptive vocabulary skills in the dominant language of bilinguals are more likely to be within monolingual norms than expressive vocabulary skills (Gibson et al., 2012; Gibson et al., 2014). The bilingual children in the current sample scored significantly lower on the expressive vocabulary measure than their English monolingual peers, but it is likely that the monolingual-bilingual difference would have been much smaller (or perhaps non-existent) on a measure of receptive vocabulary given that English was the majority language. If the monolinguals and bilinguals have similar receptive vocabularies and decoding skills, there is no reason for them to differ in performance on the LDT task.

Greek: The results for the literacy measures in Greek are in stark contrast to the findings for the majority language English, where significant group differences only emerged for reading comprehension. The group comparisons showed that the bilinguals scored significantly lower than their monolingual peers on all Greek literacy measures, except for the lexicality effect and the passage comprehension subtest (which could only be administered to bilinguals with relatively high proficiency in Greek). Moreover, all of the significant group differences disappeared after controlling for the bilingual children's lower vocabulary scores in Greek. The bilingual children's lower performance on the Greek literacy measures is not surprising given that Greek was the minority language and the fact that some children had very little exposure to Greek. However, the results for the passage comprehension subtest and the lexicality effect are unexpected. Regarding the lexicality effect, it was hypothesized that the bilinguals would show a larger effect than the monolinguals due to their lower lexical skills. However, the results showed no difference between groups which might be due to the use of reaction time data to calculate the lexicality effect. This is because only correct trials are included for the analysis of RTs, so that decoding and orthographic processing come to bear a much bigger role than vocabulary skills as such. Thus, the bilinguals were significantly less accurate than the monolinguals (due to their lower vocabulary skills), but the extent to which their responses were slowed down by the presence of pseudowords was comparable to monolinguals. This suggests that the bilinguals' orthographic processing skills were comparable to their monolingual peers, but more importantly, it shows that even children with very low oral proficiency can have orthographic processing skills and word reading abilities at monolingual levels. In some sense, their (basic) literacy skills in Greek are more advanced than what would be expected on the basis of their oral language skills. This is an interesting finding on which educators in the field of heritage language support may capitalize. For the passage comprehension subtest, the analysis included a subset of 32 bilingual children since the remaining 18 did not have sufficient literacy levels in Greek to complete the task. The results showed that the two groups did not differ in accuracy after controlling for differences in age, although there was a tendency for the Greek monolinguals to score higher than the bilinguals. Interestingly, adding vocabulary as a control variable resulted in a trend that went in the opposite direction, i.e., the adjusted means for the bilinguals were higher than for the monolinguals. On first sight, the results might suggest that the bilingual children's reading comprehension skills in the minority language Greek were comparable to monolingual children, while their reading skills in the majority language English were significantly lower compared to monolinguals. However, the findings need to be interpreted with caution because the analysis of the passage comprehension subtest in Greek only included bilinguals with relatively high proficiency in Greek, and because of the differences between the reading comprehension measures used in English and Greek. Reading comprehension consists of multiple processes, and Keenan, Betjemann and Olson (2008) have shown that reading tests differ in the extent to which they tap the various underlying processes. Nevertheless, the results for the passage comprehension subtest in Greek show that it is, in principal, possible for bilinguals to perform at monolingual levels on measures of reading comprehension. Future studies are needed to uncover the conditions under which this is the case.

Minority vs. majority language

Turning to the comparison between the bilingual children's performances in Greek and English, the analyses showed that the children performed significantly better on all English measures except for verbal WM, story length and syntactic complexity of the narratives, which did not differ between English and Greek. Verbal working memory also showed the strongest cross-linguistic association suggesting that the digit backwards task poses little demands on language-specific knowledge (i.e., it is not confounded by language proficiency). The finding that narrative length was invariant across languages corroborates previous studies (Fiestas & Peña, 2004; Uccelli & Páez, 2007), but the lack of a significant language effect for syntactic complexity is surprising given the children's rather low levels of proficiency in Greek, as indicated by their vocabulary scores. The other two microstructure measures, namely grammaticality and verb diversity showed better performance in English, with a small to moderate effect size. This is consistent with previous studies on narrative abilities in bilinguals reporting fewer grammatical errors in the children's majority language (Iluz-Cohen & Walters, 2012), and greater lexical diversity in the dominant language[38] (Simon-Cereijido & Gutiérrez-Clellen, 2009). However, some studies do not find crosslinguistic differences on measures of grammaticality (Fiestas & Peña, 2004; Gutiérrez-Clellen, 2002), but these typically involve Spanish-English bilinguals in North America who tend to have ample exposure to the minority language due to the size of the Spanish-speaking community, in contrast to the bilinguals in Europe who generally have less opportunities for exposure to the minority language. Moreover, three of the four microstructure measures showed significant associations between languages which is at odds with previous studies that failed to find crosslinguistic relationships for microstructure measures (e.g., Bedore, Peña, Gillam & Ho, 2010; Pearson, 2002; Uccelli & Páez, 2007). Note that the conclusions regarding narrative abilities in the minority and majority language of bilinguals can only be tentative since the current study does not provide a comparison with monolingual data in each language, and no macrostructure measures were included. Nevertheless, the results from the cross-language comparisons confirm that microstructure measures at the lexical level (i.e., verb diversity and grammaticality) are more likely to show differences across languages than more global measures of narrative microstructure (i.e., length, syntactic complexity). Thus, the observed pattern is largely in line with the prediction that measures that require more language-specific knowledge are more likely to show crosslinguistic differences than measures that tap less language-specific skills.

The difference between scores on the narrative comprehension questions in English and Greek yielded small to moderate effect sizes which aligns well with the results from the group comparisons (i.e., no group differences for English and relatively small differences for Greek). Previous research that has investigated narrative comprehension in bilinguals has produced mixed findings with some finding better performance in the majority language (e.g., Gutiérrez-Clellen, 2002), and others reporting no difference across languages (e.g., Bohnacker, 2016). In contrast to narrative comprehension, the bilingual children's scores for the SRT showed large differences between English and Greek. The results for narrative comprehension and SRT scores are in line with the hypothesis that productive language skills show larger differences across languages than receptive language skills (Gibson et al., 2014). For decoding skills, the difference in the performance of the bilinguals across languages was relatively small and there was a moderate to strong positive crosslinguistic correlation between scores in English and Greek. The results from the correlational analysis are in line with the findings from a meta-

[38] Note that the majority language typically becomes the children's dominant language when they enter the school system where instruction is provided in the majority language only. However, in the case of Spanish-English bilinguals in the United States, the situation is somewhat different because of the size of the Spanish-speaking community and the large number of bilingual schools which means that the children may remain dominant in the minority language Spanish for much longer.

analysis by Melby-Lervåg and Lervåg (2011) who found a moderate to strong cross-linguistic association for decoding skills, especially for children who received formal instruction in both languages. Note that the significant difference between the bilingual children's decoding skills in English and Greek is readily explained by the fact that the amount of formal schooling in Greek was very low compared to the amount of schooling received in English. Similar results were obtained for RAN, namely a significant positive correlation across languages and a moderate difference between scores in English and Greek. Thus, the results for RAN and decoding are in line with the assumption that basic literacy skills are relatively language-invariant, hence the significant crosslinguistic associations. The results for reading comprehension are difficult to interpret because of the different test formats in English and Greek. Nevertheless, the cross-language comparison of the bilingual children's performance seems to suggest significant effects of language status, with performance in the minority language being considerably lower. The comparison between the bilingual children's performance on the lexical decision task in English and Greek yielded large effect sizes. This is explained by the fact that performance on the lexical decision task is heavily dependent on lexical skills, which are known to be most vulnerable in bilinguals. The largest difference in performance between English and Greek was observed for the letter fluency task, with an associated effect size of over 1 *SD*. Similar to the lexical decision task, performance on letter fluency is heavily contingent on vocabulary skills which explains the large difference between English and Greek scores. However, performance on the letter fluency task was significantly correlated across languages, which was not the case for the measures from the LDT. The cross-linguistic association for letter fluency scores most likely reflects the large executive function component of the task.

Summary

Taken together, the present findings emphasize the importance of lexical knowledge for oral language and literacy skills. The group comparisons showed that expressive vocabulary is by far the most vulnerable linguistic domain in bilinguals since it produced the largest group effect among all the measures in both English and Greek. This is consistent with previous research and is readily explained by the fact that vocabulary development is highly contingent on linguistic input in each language, which is typically reduced in bilinguals compared to monolinguals. Moreover, vocabulary is highly language-specific which is further reflected in the strong negative correlation between the two vocabulary scores in the current sample. For the majority language English, moderate group differences emerged in reading comprehension and sentence repetition, but these were largely attributable to the bilinguals' lower vocabulary. In contrast, the present results suggest that skills at the interface between executive functions and phonological processing (i.e., verbal working memory) are enhanced in bilinguals. Thus, it is possible that bilinguals are able to compensate for their lower language proficiency by relying on their superior executive function abilities to perform at equal levels as their monolingual peers on measures of basic reading skills in the majority language English. However, for the minority language Greek, the gap in language proficiency was too big for the bilinguals to be compensated for by other skills.

CHAPTER 4 – PREDICTORS OF READING

4.1 Research questions & hypotheses

The aim of this chapter is to investigate predictors of reading, i.e., single word decoding and reading comprehension, in monolingual and bilingual children in two languages that differ in orthographic transparency, English and Greek. Previous research that compared reading development in monolingual and bilingual children and studies looking at monolingual reading development across languages have shown both differences and similarities. On the one hand, word reading and reading comprehension have been shown to be predicted, by and large, by the same set of predictors regardless of orthographic transparency and bilingualism. On the other hand, crosslinguistic differences as well as differences between monolingual and bilingual learners have been observed in terms of the relative contribution of the various predictors, although not consistently so. One major source of variability across studies is the use of different measures to represent the underlying skills and constructs. However, no study could be located that has investigated effects of bilingualism and orthographic transparency at the same time. The group (monolingual vs. bilingual) by language (English vs. Greek) design employed in the current study offers the possibility to compare predictors of reading across groups and languages using the same set of tasks (with the exception of reading comprehension which used a different task format in English and Greek). The specific research questions addressed in this chapter are:

i. *Do the relative contributions of vocabulary, RAN and verbal working memory to word reading accuracy differ as a function of orthographic consistency and group?*

Previous research suggests that both RAN and verbal working memory contribute to word reading in monolinguals and bilinguals regardless of orthographic transparency (Caravolas et al., 2012a; Geva & Siegel, 2000; Geva et al., 2000). Although some researchers have argued for crosslinguistic differences in terms of the relative contribution of RAN (e.g., Landerl & Wimmer, 2008), when equivalent measures are used the RAN-reading relationship does not seem to be affected by orthographic transparency (Caravolas et al., 2012a; Ziegler et al., 2010). Thus, RAN is expected to be an equally good predictor of word reading accuracy in English and Greek. Verbal working memory shares a considerable amount of variance with phonological awareness skills and consequently, only makes a small independent contribution to basic reading skills (Gottardo et al., 1996). The relatively small unique effect of verbal WM might be the reason why no study to date has explicitly compared its relationship with word decoding in monolingual children across different languages. However, Geva and Siegel (2000) compared the relationship between memory skills and word reading in the two languages of English-Hebrew bilinguals and found that memory skills accounted for more variance in English than in (vowelized) Hebrew pointing to effects of orthographic transparency. Based on the finding that monolinguals and bilinguals acquire basic reading skills in a highly similar manner (Geva et al., 2000; Verhoeven, 2000), it is predicted that verbal working memory will play a more important role in English compared to Greek for both monolinguals and bilinguals. Given the highly inconsistent findings regarding the role of vocabulary across different languages, it is difficult to make any clear predictions. Assuming that vocabulary supports whole-word reading which is a crucial factor in developing reading fluency in opaque orthographies like English, it is predicted that lexical abilities will exert a bigger influence on word reading in English compared to Greek (Suggate et al., 2014). Moreover, vocabulary is expected to exhibit a stronger relationship with word decoding in the bilinguals, since previous research suggests that oral language skills play a more prominent role in bilingual than in monolingual reading development (Babayiğit, 2015; Droop & Verhoeven, 2003).

ii. *Do other oral language skills and executive function skills explain additional variance in word reading accuracy in English and Greek monolingual and bilingual children?*

Because the present study used a single word reading task to assess reading accuracy, listening comprehension is unlikely to explain additional variance once individual differences in vocabulary have been accounted for. On the other hand, performance on the sentence repetition task might show an association with word reading because the ability to repeat a sentence verbatim implicates working memory as well as grammatical competence (Riches, 2012). Only few studies have examined the possible contribution of executive function skills to word reading, so predictions can only be tentative. Nevertheless, both inhibition and switching have been associated with decoding skills in English (Altemeier et al., 2008). Hence, additional contributions of EF skills to word decoding are anticipated, especially for tasks that use verbal stimuli (Messer et al., 2016).

iii. *Do the relative contributions of decoding and oral language skills to reading comprehension differ as a function of orthographic consistency and group?*

Previous research has shown a developmental shift in the relative contribution of oral language skills and decoding to reading comprehension. More specifically, the contribution of decoding has been found to decrease throughout primary school as children reach ceiling on measures of word reading accuracy, while the contribution of oral language skills increases as the content of the reading material becomes more difficult (Catts et al., 2005; Gough et al., 1996). Since the children in the current sample were attending Year 3-6 at primary school, they were assumed to have mastered basic reading skills. Thus, it is anticipated that reading comprehension will show a stronger relationship with oral language skills than with decoding in both languages. However, it is possible that the contribution of decoding skills will be larger in

English compared to Greek because children develop word reading skills faster in languages with transparent orthographies compared to languages with opaque orthographies (Seymour et al., 2003). Consequently, it is likely that word reading skills exert an influence on reading comprehension for longer in inconsistent orthographies like English compared to transparent orthographies. In terms of differences between groups, oral language skills are expected to show a stronger relationship with reading comprehension in bilinguals as has been reported in previous studies (Droop & Verhoeven, 2003; Verhoeven & van Leeuwe, 2012). In contrast, the contribution of decoding skills should not differ across groups since monolinguals and bilinguals develop basic literacy skills at equal rates (Melby-Lervåg & Lervåg, 2014).

iv. Do RAN and executive function skills explain additional variance in reading comprehension in English and Greek monolingual and bilingual children?

Both RAN and working memory have been linked to reading comprehension in monolingual and bilingual children (Arnell, Joanisse, Klein, Busseri & Tannock, 2009; Morfidi, van der Leij, de Jong, Scheltinga & Bekebrede, 2007; Sesma et al., 2009; Swanson, 2015). Moreover, there is evidence that executive function skills such as inhibition and switching are related to reading ability (Altemeier et al., 2008). However, the various executive function components have been indexed by very different tasks which makes it difficult to compare findings for monolinguals and bilinguals across studies. Nevertheless, it is anticipated that RAN and executive function abilities will make significant contributions to reading comprehension in monolinguals and bilinguals alike.

4.2 Data analyses

The research questions were addressed by running a series of multiple hierarchical regression models. Before conducting the main analyses, bivariate correlations were computed in order to identify potential issues with multicollinearity. The predictor variables that were included in the analyses were vocabulary, the three scores from the SRT (accuracy, grammaticality and structure scores), scores for the two types of comprehension questions (factual and mental), digit backwards, Mr. X and 2-back scores, the two measures of inhibition and switching, letter fluency and RAN. The dependent variables were the decoding and the reading comprehension measures. Recall that the single word reading test in English only included real words while the Greek decoding measure included both real and pseudowords. However, to keep the analyses as similar as possible across languages, only scores on the real words were used to index decoding skills in Greek. For reading comprehension in Greek, the composite scores derived from the two subtests (sentence matching and passage comprehension) were used in order to keep the sample as large as possible[39]. High correlations between some of the measures were anticipated, especially those that were derived from the same task (e.g., SRT). Measures that showed strong associations with each other were subjected to a Principal Component Analysis (PCA) from which composite scores could be computed. Next, multiple hierarchical regressions were conducted on decoding and reading comprehension scores for each language and group. The order of entry of predictor variables was semi-fixed. For the analyses of decoding skills, age and non-verbal IQ were always entered at the first step. Vocabulary, RAN and verbal WM were entered at subsequent steps (i.e., 2-4) and the analyses were repeated with the variables of interest entered in different orders to examine their unique effects on word reading. This was followed by some additional exploratory analyses where each of the variables that were not included in the initial model was added to see whether they made a significant contribution. Moreover, a commonality analysis was conducted to determine the amount of unique and common variance explained by the various predictor variables (Nimon, 2010). For the regression analyses of reading comprehension, age and non-verbal IQ were again entered at the first step. Next, the composite scores for oral language were added to the model at step 2 and the decoding measure at step 3. The analyses were repeated with the order of entry of the last two variables reversed in order to examine the independent contribution of oral skills and decoding to reading comprehension. The possible contribution of the various cognitive measures was examined by adding the additional predictors to the models at step 4. Finally, a commonality analysis was run to determine the unique and total contributions of the predictor variables.

4.3 Results: Correlations

4.3.1 English

The simple bivariate correlations between the dependent and the predictor variables for English are given in Table 31 (coefficients for the bilinguals are presented in the upper diagonal and values for the English monolinguals are in the lower diagonal). For both groups, scores on the two types of comprehension questions (factual questions and questions about mental states of characters), as well as the two measure derived from the Global-Local task (i.e., inhibition and switching) did not show significant correlations with word reading. For the bilinguals, all other predictor variables showed small to moderate correlations with the decoding measure (*r*s between .322 and .588, *p*s<.05). For the monolinguals, non-verbal IQ, vocabulary and grammaticality scores on the SRT also failed to show a significant correlation with the decoding measure with the remaining predictor variables yielding coefficients between .297 and .486 (all

[39] Recall that some of the bilingual children did not have sufficient literacy skills in Greek to read connected text and thus, could not be administered the reading comprehension tasks in Greek.

*p*s<.05). Overall, the correlations between the various predictor variables and decoding were weaker in the monolingual sample compared to those for the bilinguals. For the second outcome measure of interest, namely reading comprehension, the coefficients for the bilinguals show significant associations with all predictor variables (*r*s between .331 and .685, *p*s<.05) except the comprehension questions, 2-back scores and the measure of inhibition. In contrast, for the L1-English only a few of the predictor variables showed significant correlations with reading comprehension, namely non-verbal IQ ($r(58)=.414$, $p<.001$), SRT-accuracy ($r(58)=.335$, $p=.010$) and SRT-grammaticality scores ($r(58)=.329$, $p=.012$). For the bilinguals, there were strong correlations among the three measures from the SRT and vocabulary (*r*s ranging between .591 and .872, *p*s<.001), while for the monolinguals the three SRT measures showed moderate correlations with each other (*r*s between .325 and .578, *p*s<.05), but no significant associations with vocabulary scores. Moreover, the three predictor variables that involve phonological processing, namely digit backwards, Rapid Automatized Naming (RAN) and letter fluency (LF) showed small to moderate correlations with each other in both groups (BL: *r*s between .410 and .465, *p*s<.01; ML: *r*s between .303 and .378, *p*s<.05). Finally, LF significantly correlated with vocabulary and the SRT measures in the bilingual sample (*r*s between .366 and .418, *p*s<.01), while no such significant associations were present in the L1-English group.

Table 31. *Correlations (Pearsons's r) between variables used in the analyses for English.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Age	--	-.158	-.007	.015	-.223	-.113	.112	.007	.245†	.347*	.359**	-.232	-.539***	.064	-.192	.347*	.331*
2. NVIQ	-.375**	--	.494***	.343*	.363**	.373**	-.107	.206	.489***	.371**	.055	.104	.054	.338*	-.349*	.494***	.418**
3. Vocabulary	.032	.145	--	.620***	.657***	.591***	-.179	.094	.188	.411**	-.107	.006	-.122	.418**	-.287*	.478***	.619***
4. SRT-acc	-.070	.286*	.149	--	.836***	.872***	-.183	.045	.246†	.274†	-.027	.015	-.086	.375**	-.222	.420**	.685***
5. SRT-gram	-.209	.127	.241†	.325*	--	.808***	-.226	.026	.218	.242†	-.048	.038	.036	.394**	-.173	.322*	.568***
6. SRT-struct	.045	.083	.086	.578***	.496***	--	-.293*	-.011	.258†	.169	-.115	.161	.025	.366**	-.281*	.356*	.526***
7. CQ-factual	.042	.227†	.333*	.064	.237†	.173	--	.314*	-.322*	.100	.150	.096	-.046	-.234	.032	-.036	-.134
8. CQ-mental	-.025	.144	.311*	.068	.149	.082	.213	--	-.032	.123	-.089	.225	.076	<.001	-.047	.200	.113
9. DB	.276*	.082	.059	.196	-.099	.142	.213	.193	--	.388**	.340*	-.060	-.210	.453***	-.465***	.588***	.482***
10. Mr. X	.277*	.097	.049	.094	-.063	.276*	.197	-.053	.120	--	.368**	.040	-.241†	.148	-.317*	.465***	.427**
11. 2-back	-.084	.367**	.256†	.441***	-.045	.225†	.180	.047	.140	.130	--	-.059	-.338*	.119	-.190	.332*	.121
12. Inhibition	-.100	-.019	-.184	.064	-.111	.024	-.064	.020	-.080	-.172	-.090	--	.355*	.055	-.107	.089	-.124
13. Switching	-.249†	-.041	.022	-.003	.139	.150	-.087	-.058	-.189	-.087	.095	-.066	--	-.254†	.342*	-.226	-.432**
14. LF	.474***	-.183	.040	.053	-.074	.138	-.196	-.019	.303*	.026	-.037	-.123	-.024	--	-.410**	.417**	.396**
15. RAN	-.286*	.031	.160	-.031	.298*	-.050	.066	.007	-.378**	-.214	-.042	-.112	.161	-.345**	--	-.546***	-.357*
16. Decoding	.365**	.116	.070	.297*	-.109	.320*	-.065	.041	.382**	.380**	.331*	-.182	-.162	.486***	-.460**	--	.683***
17. RC	.176	.414***	.227†	.335**	.329*	.227†	.234†	.130	.053	.059	.213	-.066	-.106	.075	.169	.200	--

Note. Bilinguals above diagonal, monolinguals below diagonal; NVIQ = non-verbal IQ; SRT-acc = SRT-accuracy; SRT-gram = SRT-grammaticality; SRT-struct = SRT-structure; CQ = comprehension questions; DB = digit backwards; LF = letter fluency; RAN = rapid automatized naming; RC = reading comprehension

†p<.01; *p<.05; **p<.01; ***p<.001

4.3.2 Greek

The coefficients for the simple bivariate correlations (Pearson's *r*) between the dependent and the predictor variables are presented in Table 32 (values for the bilinguals are in the upper diagonal and the coefficients for the Greek monolinguals in the lower diagonal). Non-verbal IQ, scores for the two types of comprehension questions and the measures of inhibition and switching did not show significant correlations with decoding in either group[40]. Apart from Mr. X scores, all other predictor variables showed significant correlations with decoding in the bilingual group (*r*s between .313 and .546, *p*s<.05). For the Greek monolinguals, 2-back scores and grammaticality and structure scores from the SRT also failed to show significant correlations with the decoding measure. The coefficients for the correlations that did reach significance in the monolingual group ranged between .274 and .539 (all *p*s<.05). On the whole, the associations between the various predictor variables and the decoding measure were stronger in the bilingual sample compared to the monolinguals. Turning to reading comprehension, the results for the bilinguals showed significant correlations with the majority of the predictor variables with coefficients ranging between .302 and .749 (all *p*s<.05). The variables that did not show significant associations with reading comprehension scores in the bilingual sample were the comprehension questions (both factual and mental), 2-back scores, inhibition and switching. For the Greek monolinguals, the only variables that did not show significant correlations with reading comprehension were scores on the comprehension questions probing mental states of characters and the measure of inhibition. All other predictor variables correlated significantly with reading comprehension with coefficients ranging from .247 and .719 (all *p*s<.05). For the bilinguals, vocabulary scores and the three scores from the SRT showed strong correlations with each other (*r*s between .709 and .896, *p*s<.001). In the monolingual sample, the three SRT scores were also highly correlated (between .690 and .829, *p*s<.001), while the correlations between vocabulary and SRT scores were considerably weaker than in the bilingual sample (*r*s between .282 and .440, *p*<.05). The three predictor variables with a phonological component (i.e., digit backwards, RAN and letter fluency) showed moderate correlations with each other in both groups, although the coefficients were slightly higher for the bilinguals (BL: *r*s between .443 and .572, *p*s<.001; ML: *r*s between .371 and .408, *p*s<.01). Scores on the letter fluency task also showed strong correlations with vocabulary and the three SRT scores in the bilingual group (*r*s between .501 and .600, *p*s<.001). The associations were also present in the Greek monolinguals, but were considerably weaker than in the bilingual group (*r*s between .217 and .463, *p*s<.08).

[40] Although the correlation between switching and decoding was marginally significant for the English monolinguals (*r*(64)=-.220, *p*=.081).

Table 32. *Correlations (Pearsons's r) between variables used in the analyses for Greek.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Age	--	-.158	.379**	.324*	.317*	.186	.073	-.240†	.374**	.347*	.359**	-.232	-.539***	.420**	-.359*	.510***	.388**
2. NVIQ	.084	--	-.040	-.127	-.139	-.177	.128	.006	.401**	.371**	.055	.104	.054	.036	-.052	.097	-.330*
3. Vocabulary	.484***	.332**	--	.835***	.709***	.737***	.079	.214	.448***	-.158	.186	-.197	-.224	.600***	-.623***	.449***	.749***
4. SRT-acc	.521***	.112	.440***	--	.896***	.859***	.011	.156	.466***	-.201	.245†	-.184	-.206	.598***	-.657***	.533***	.749***
5. SRT-gram	.352**	.022	.282*	.829***	--	.870***	.109	.195	.413**	-.122	.260†	-.191	-.239	.528***	-.699***	.484***	.638***
6. SRT-struct	.424***	.087	.284*	.721***	.690***	--	-.069	.203	.293*	-.295*	.149	-.072	-.147	.501***	-.658***	.313*	.655***
7. CQ-factual	.332**	.049	.256*	.326**	.218†	.285*	--	.433**	.319*	.151	.075	-.091	-.303*	.225	-.353*	.159	-.056
8. CQ-mental	.168	.059	.050	.049	-.043	.031	.205	--	.002	-.080	-.025	.136	.009	.054	-.292*	.041	-.044
9. DB	.372**	.265*	.305*	.405***	.279*	.301*	.190	-.083	--	.293*	.166	-.103	-.241†	.572***	-.443***	.546***	.302*
10. Mr. X	.382**	.337**	.404***	.107	.163	.084	.069	-.196	.383**	--	.368**	.040	-.241†	-.017	-.042	.255†	-.444**
11. 2-back	.207	.112	.153	.167	.154	.064	-.052	.093	.163	.219†	--	-.059	-.338*	.261†	-.128	.331*	.004
12. Inhibition	-.037	-.156	-.087	.057	.012	-.073	-.214†	-.063	.082	-.283*	.072	--	.355*	-.128	.147	-.115	-.242
13. Switching	-.073	-.261*	-.149	-.070	<.001	-.081	-.056	.068	-.331**	-.326**	-.055	.273*	--	-.383**	.274†	-.207	-.251
14. LF	.548***	.053	.463***	.335**	.214†	.278*	.209†	.112	.371**	.152	.198	-.132	-.281*	--	-.483***	.487***	.588***
15. RAN	-.488***	.024	-.192	-.405***	-.398***	-.392***	-.126	-.091	-.408***	-.326**	-.172	.076	.101	-.388***	--	-.437**	-.625***
16. Decoding	.449***	.190	.442***	.274*	.220†	.160	.087	.163	.383**	.327**	.200	-.048	.220†	.344**	-.539***	--	.637***
17. RC	.719***	.321**	.527***	.534***	.334**	.484***	.247*	.050	.504***	.470***	.252*	-.150	-.343**	.541***	-.466***	.555***	--

Note. Bilinguals above diagonal, monolinguals below diagonal; NVIQ = non-verbal IQ; SRT-acc = SRT-accuracy; SRT-gram = SRT-grammaticality; SRT-struct = SRT-structure; CQ = comprehension questions; DB = digit backwards; LF = letter fluency; RAN = rapid automatized naming; RC = reading comprehension

†*p*<.01; **p*<.05; ***p*<.01; ****p*<.001

4.4 Calculation of composite scores

Prior to the main analyses, Principal Component Analyses (PCA) were carried out in order to avoid multicollinearity in the regression models and to reduce the number of predictor variables. The simple bivariate correlations showed strong associations between SRT scores (accuracy, grammaticality and structure) and vocabulary in both English and Greek. Hence, a composite score for oral language skills was computed on the basis of vocabulary scores and the three SRT scores in each language. Scores from the comprehension questions were not included as the correlations with the other measures were very low (all *r*s<.350, see Tables 31 and 32)[41]. In the English data, the four variables (vocabulary and SRT scores) were strongly correlated (*r*s for the whole sample between .554 and .801) and showed good factorability (KMO=.807; Bartlett's test of sphericity $\chi^2(6)=275.4$, $p<.001$). The factor (i.e., composite score) extracted from the four variables accounted for 76.3% of the variance and showed good internal consistency (Cronbach's $\alpha=.886$). The factor loadings used to calculate the composite scores for oral language skills in English, as well as their communalities are given in Table 33. In the Greek data, the correlations for the total sample among the four variables were even higher than in English and ranged between .713 and .906. The four variables showed good sampling adequacy for the analysis (KMO=.804; Bartlett's test of sphericity $\chi^2(6)=486.7$, $p<.001$) and the extracted factor (i.e., the composite score) accounted for 84.4% of the variance. The resulting oral language composite score showed good internal consistency (Cronbach's $\alpha=.785$). The factor loadings and communalities for the four variables are given in Table 34.

Table 33. *Factor loadings and communalities based on a principal component analysis for the four variables used to calculate the oral language composite score in English.*

	Factor loading	Communality
Vocabulary	.780	.609
SRT-acc	.890	.792
SRT-gram	.911	.829
SRT-struct	.906	.820

Table 34. *Factor loadings and communalities based on a principal component analysis for the four variables used to calculate the oral language composite score in Greek.*

	Factor loading	Communality
Vocabulary	.879	.772
SRT-acc	.964	.930
SRT-gram	.939	.882
SRT-struct	.935	.874

[41] A preliminary PCA that included the scores for the two types of comprehension questions also suggested that they load on a separate factor. This was the case in both English and Greek.

4.5 Results: Regressions

4.5.1 Decoding

A series of hierarchical regression analyses were conducted to examine the interrelationships between the decoding measure and the various predictor variables in each group and language. The results are summarized in Table 35 which shows the changes in R^2 for each step in the analyses. Age and non-verbal IQ made large contributions to word reading in both groups and languages. In the bilingual sample, age and non-verbal IQ accounted for 42.9% of the total variance in English decoding, while in the monolingual group, their contribution was considerably smaller with 20.8%. Similar values were obtained for Greek decoding where age and non-verbal IQ explained 22.7% and 29.3% of variance in monolinguals and bilinguals, respectively. When entered at step 2, vocabulary made a significant contribution in Greek for both groups, whereas in English it came out as a significant predictor for the bilingual, but not the monolingual sample. Moreover, for the bilinguals, the amount of variance explained by vocabulary was slightly higher in Greek compared to English (ENG: 5.5%; GR: 7.4%) and also relative to Greek monolinguals (5.5%). However, when entered at the last step, vocabulary did not account for additional variance in Greek for the bilinguals showing that it contributed to word reading mainly through shared variance with verbal WM and RAN. Rapid naming made a significant independent contribution to word decoding in both monolingual groups (L1-English: 8.7%; L1-Greek: 11.6%). For the bilinguals in Greek, RAN made a significant contribution when entered at step 2 (6.4%), but not when it was entered after vocabulary or verbal WM. For the bilinguals in English, RAN was a significant predictor when it was added at step 3, but its contribution was only marginally significant (3.6%) when both vocabulary and verbal WM were included in the model. In the two monolingual control groups, verbal WM did not account for a significant amount of additional variance when entered at the final step. However, when entered at step 3 after vocabulary, verbal WM did make a small contribution to word decoding in both monolingual groups (L1-English: 5.8%; L1-Greek: 3.4%), although it was only marginally significant for Greek. For the bilinguals, verbal WM made a significant contribution to word reading independently from the other predictor variables (English: 4.4%; Greek: 5.5%). When entered at step 2, verbal WM contributed nearly twice as much variance in Greek compared to English (GR: 11.4%; ENG: 6.5%). In terms of total amount of variance explained by the five predictor variables, the full model accounted for 60% of variance in English decoding for the bilingual sample, whereas the amount for English monolinguals was considerably lower at 35.3%. For Greek decoding, the set of predictors accounted for a similar amount of variance in the two groups (BL: 43.6%; ML: 43.1%).

As an exploratory analysis, the remaining variables that were not included in the initial models were added at a subsequent step 5 to see whether any of them were able to account for additional variance in word reading skills. For English word decoding, the analyses yielded no additional predictors for the bilinguals. For the English monolinguals, SRT-accuracy, SRT-structure, 2-back and letter fluency scores each explained additional variance beyond the variables included in the initial model (4.8%, 6.1%, 6.3% and 6.6%, respectively). Among these four additional predictors, only 2-back and LF made independent contributions (3.8% and 5.8%), while the two SRT scores did not come out as significant predictors when LF and 2-back scores were included in the model as competitors. For Greek decoding, SRT-accuracy scores explained a significant amount of additional variance in the bilinguals (6%), whereas no other predictors emerged in the monolingual group.

Table 35. *Summary of hierarchical regression analyses showing R^2 changes for decoding measure in English and Greek.*

	English decoding		Greek decoding	
Step, Predictor	*Bilinguals*	*L1-English*	*Bilinguals*	*L1-Greek*
1. Age, NVIQ	.429***	.208**	.293***	.227***
2. Vocabulary	.055*	<.001	.074*	.055*
3. RAN	.072**	.128**	.014	.145***
4. Verbal WM	.044*	.017	.055*	.005
3. Verbal WM	.080**	.058*	.062*	.034†
4. RAN	.036†	.087*	.006	.116**
2. RAN	.087**	.121**	.064*	.141***
3. Verbal WM	.031†	.019	.071*	.008
4. Vocabulary	.053*	.005	.008	.055*
3. Vocabulary	.040*	.007	.025	.058*
4. Verbal WM	.044*	.017	.055*	.005
2. Verbal WM	.065*	.058*	.114**	.040†
3. Vocabulary	.070**	<.001	.023	.048*
4. RAN	.036†	.087*	.006	.116***
3. RAN	.053*	.083*	.021	.109**
4. Vocabulary	.053*	.005	.008	.055*

Note. NVIQ = non-verbal IQ; RAN = rapid automatized naming; WM = working memory
†p<.01; *p<.05; **p<.01; ***p<.001

In order to gain more insight into the structure of covariances between the predictor variables in the main regression analyses, commonality analyses were conducted. The results from the analyses are summarized in Table 36. For English, age accounted for a similar amount of variance in both groups (BL: 12%; ML: 13.3%) with similar independent contributions (BL: 5.9%; ML: 6.9%). The overall effect of non-verbal IQ was negligible for the English monolinguals (1.3%), while it made a large contribution to word decoding in bilinguals (24.4%) although it was almost entirely shared with the other predictor variables (unique contribution: 1.9%). Vocabulary accounted for 5.3% of individual variance in bilinguals with a total contribution of 22.9%, while it did not contribute to word reading in English monolinguals. Rapid naming was a strong predictor of decoding skills in both groups, but more so in the bilingual sample (BL: 29.8%; ML: 21.1%). However, RAN shared more variance with the other predictors in the bilinguals as its unique contribution was only 3.6% compared to 8.7% in the English monolinguals. Verbal WM overall made a larger contribution in bilinguals compared to the monolinguals (BL: 34.6%; ML: 14.6%), but its contribution in both groups was largely mediated by the other predictor variables leaving little unique variance attributable to verbal WM (BL: 4.4%; ML: 1.7%).

Turning to Greek, age had a large effect on decoding skills in both groups (BL: 26%; ML: 20.2%). Moreover, it made a unique contribution of 6.8% in the bilingual sample, whereas in the Greek monolinguals its effect was mediated by the other predictor variables leaving only 0.3% of unique variance to age. The role of non-verbal IQ was negligible in both groups with total contributions of less than 4%. Vocabulary was a strong predictor of word reading in both groups with similar amounts of total variances (BL: 20.2%; ML: 19.5%) although most of the contribution was again shared with the other predictor variables resulting in little unique variance (BL: 0.8%; ML: 5.5%). Rapid naming was the strongest predictor in the monolingual sample both in terms of unique and total variance explained (11.6% and 29%, respectively). For the bilinguals, RAN was also a strong predictor of decoding skills (19.1%), but nearly all of the variance was shared with the other predictors leaving a mere 0.6% of unique variance. Verbal WM had a large effect on decoding skills in the bilinguals with a total contribution of 29.8%, while in the monolingual sample the total amount of variance explained by WM was much less with 14.7%. For the monolinguals, the effect of verbal WM was almost entirely mediated by the other predictors (1% of unique variance). In contrast, in the bilinguals sample verbal WM uniquely accounted for 5.5% of the total variance in word reading.

Table 36. *Unique, common and total contributions of the predictor variables in the regression models for decoding in English and Greek.*

	English decoding					
	Bilinguals			L1-English		
	Unique	*Common*	*Total*	*Unique*	*Common*	*Total*
1. Age	.059	.062	.120	.069	.064	.133
2. non-verbal IQ	.019	.225	.244	.038	-.025	.013
3. Vocabulary	.053	.176	.229	.005	<.001	.005
4. RAN	.036	.262	.298	.087	.124	.211
5. verbal WM	.044	.302	.346	.017	.128	.146

	Greek decoding					
	Bilinguals			L1-Greek		
	Unique	*Common*	*Total*	*Unique*	*Common*	*Total*
1. Age	.068	.193	.260	.003	.199	.202
2. non-verbal IQ	.000	.009	.009	.005	.031	.036
3. Vocabulary	.008	.194	.202	.055	.140	.195
4. RAN	.006	.184	.191	.116	.174	.290
5. verbal WM	.055	.243	.298	.010	.137	.147

4.5.2 Reading comprehension

Hierarchical multiple regressions were conducted in order to investigate the predictors of reading comprehension in monolingual and bilingual children speaking English and Greek. The changes in R^2 for the various steps of the analyses are presented in Table 37. Age and non-verbal IQ made a substantial contribution to reading comprehension in both groups and languages. The effect of the two variables was largest in the Greek monolinguals where they accounted for 58.6% of the total variance. The amount of variance explained by age and non-verbal IQ was comparable across groups in the English data (BL: 33.7%; ML: 29.9%), while their contribution was considerably smaller for the bilinguals in Greek (19.7%). For the bilinguals, oral language skills accounted for a good 20% of variance in both languages, independently from age, non-verbal IQ and decoding skills. In contrast, the independent contribution of oral skills was about half as much in the English monolinguals (9%), while for the Greek monolinguals it had no significant effect on reading comprehension once individual differences in decoding skills were accounted for. When entered at step 2, decoding made fairly large contributions in the bilingual data in both languages (ENG: 16.1%; GR: 27.4%), a small contribution in the Greek monolinguals (4.7%), and no significant contribution in English monolinguals. However, for the bilinguals the effect was mediated by oral skills so that the amount of variance explained was reduced to around 5% in both languages when oral language skills were entered in a previous step. This was not the case for the Greek monolinguals where the contribution of decoding was only minimally reduced with the inclusion of oral skills in the model (4.1%).

For English, the subsequent analyses with the various cognitive measures entered at step 4 yielded no significant contributions of any of the measures with the exception of switching in the bilingual sample (accounting for 5.3% of additional variance) and RAN in the monolingual group (5.6% additional variance). For Greek, the analyses yielded two more significant predictors in the bilingual group and one more for the monolinguals. For the bilinguals, visual WM (Mr. X scores) and updating (2-back scores) made significant contributions of 9.4% and 6.1%, respectively. However, when both variables were added and updating was entered after visual WM at step 5, it was only a marginally significant predictor (2.1%) suggesting that its effect on reading comprehension was at least partly mediated by visual WM. In contrast, the contribution of visual WM remained significant even after accounting for individual differences in updating skills although the amount of explained variance was reduced from 9.4% to 5.4%. For the monolinguals, switching explained 3.8% of additional variance in reading comprehension. With regard to the total amount of variance accounted for by the set of predictor variables, the initial model for the bilinguals in English with age, non-verbal IQ, decoding and oral language skills as predictors explained 69.1% of the total variance and the final model that included switching explained 74.4% of variance in reading comprehension. For the English monolinguals, the amount of explained variance was much less with 38.9% in the initial model without RAN and 44.6% in the final model. For Greek, the initial model accounted for 67.2% of the total variance and the final model that included visual WM and updating accounted for 78.7% of the total variance. For the Greek monolinguals the initial model explained 65.1% of the total variance and the final model that included switching explained 68.9% of the total variance in reading comprehension.

Table 37. *Summary of hierarchical regression analyses showing R^2 changes for the measure of reading comprehension in English and Greek.*

	English RC		Greek RC	
Step, Predictor	*Bilinguals*	*L1-English*	*Bilinguals*	*L1-Greek*
1. Age, NVIQ	$.337^{***}$	$.299^{***}$	$.197^{*}$	$.586^{***}$
2. Oral language	$.303^{***}$	$.083^{**}$	$.423^{***}$	$.028^{*}$
3. Decoding	$.051^{**}$	.007	$.052^{*}$	$.041^{**}$
2. Decoding	$.161^{***}$	<.001	$.274^{***}$	$.047^{**}$
3. Oral language	$.193^{***}$	$.090^{**}$	$.200^{***}$	$.022^{\dagger}$

$^{\dagger}p<.01$; $^{*}p<.05$; $^{**}p<.01$; $^{***}p<.001$

The structure of covariances among the predictors in the main regression analyses was again examined by means of commonality analyses (see Table 38). For English, age explained 11% of variance in reading comprehension in bilinguals, with roughly half of it being variance shared with the other predictors (5.2%). In the English monolingual group, age made a unique contribution of 12%, although the negative value for its common contribution suggests that it works as a suppressor which is likely due to the negative correlation between age and non-verbal IQ in the English monolingual group ($r(58)=-.375$, $p=.004$, see Table 31). Non-verbal IQ was a good predictor in both groups with a total contribution of 17.5% in bilinguals and 17.2% in monolinguals. For the bilinguals, nearly all of the variance explained by non-verbal IQ was shared with the other predictors (17.1%). In the monolingual group, non-verbal IQ was again a suppressor although the effect was very small (2.3%) compared to its unique contribution (19.5%). Oral language was a very strong predictor in the bilingual group with a total contribution of 44%, nearly half of which was unique (19.3%). The effect of oral skills on reading comprehension was much smaller in the English monolinguals with a total contribution of 15.4% of which 9% was unique variance. Decoding skills was the best predictor of reading comprehension in the bilingual group with a total contribution of 46.6% although most of it was shared with the other predictors (mainly oral skills) resulting in a unique contribution of 5.1%. In contrast, in the monolingual group decoding skills only had a very small effect on reading comprehension as the total contribution was a mere 4%.

Turning to Greek reading comprehension, age accounted for 15% of variance in the bilinguals, most of which was shared with the other predictors leaving only 1.9% of unique variance. For the Greek monolinguals, age had a large effect on reading comprehension with a total contribution of 51.7% although only about one third of the total contribution was uniquely attributable to age (15.7%), the remaining 36% being variance shared with the other predictor variables. The effect of non-verbal IQ was similar across groups with a total contribution of 10.9% in the bilinguals and 10.3% in the monolinguals. The individual contribution of non-verbal IQ in the monolingual group was 4.1%, while in the bilingual group its unique effect was even smaller with 1.4%. Oral language skills had a large effect on reading comprehension scores in both groups, but more so in the bilingual group (BL: 54.2%; ML: 31.2%). As with most of the variables, the majority of the effect was shared with the other predictor variables in the monolingual group leaving a unique contribution of 2.2%. In contrast, oral language skills made a substantial independent contribution of 20% to reading comprehension in the bilinguals. Decoding was another strong predictor in both groups with a total contribution of 40.5% in the bilinguals and 30.8% in the monolinguals. The unique contribution of decoding was 5.2% in the bilingual group and 4.1% in the monolinguals.

Table 38. *Unique, common and total contributions of the predictor variables in the regression models for reading comprehension in English and Greek.*

	English reading comprehension					
	Bilinguals			L1-English		
	Unique	*Common*	*Total*	*Unique*	*Common*	*Total*
1. Age	.058	.052	.110	.120	-.089	.031
2. non-verbal IQ	.004	.171	.175	.195	-.023	.172
3. Oral language skills	.193	.247	.440	.090	.064	.154
4. Decoding	.051	.415	.466	.007	.033	.040

	Greek reading comprehension					
	Bilinguals			L1-Greek		
	Unique	*Common*	*Total*	*Unique*	*Common*	*Total*
1. Age	.019	.131	.150	.157	.360	.517
2. Non-verbal IQ	.014	.094	.109	.041	.062	.103
3. Oral language skills	.200	.342	.542	.022	.290	.312
4. Decoding	.052	.353	.405	.041	.268	.308

4.6 Discussion

This chapter investigated the predictors of single word reading and reading comprehension in bilingual and monolingual children speaking English and Greek. More specifically, the first research question asked whether the relative contributions of vocabulary, rapid automatized naming (RAN), and verbal working memory to word reading accuracy differ as a function of orthographic consistency and group. The second research question pertained to possible additional contributions of other oral language and executive function skills to word reading. The third research question concerned the relative contributions of decoding and oral language skills to reading comprehension as a function of orthographic consistency and group. The fourth research question addressed in this chapter asked whether RAN and executive function skills explain additional variance in reading comprehension. The above questions were investigated by running a series of multiple hierarchical regressions. In addition, commonality analyses were conducted to examine the underlying structure of covariances among the predictor variables. Prior to the main analyses, correlations among the various variables were examined to identify potential issues with multicollinearity. The following sections summarize the results and revisit the four research questions in turn.

Correlations

For English, the decoding measure showed small to moderate correlations with most of the predictor variables in both the bilingual and the monolingual children. For the English monolinguals, the only variables that correlated with reading comprehension were non-verbal

IQ, and the grammaticality and structure scores from the SRT. In contrast, the bilingual data showed correlations between reading comprehension and all predictor variables except the comprehension questions, and the measures of inhibition and updating skills. In fact, in both the English and Greek datasets, scores on the two types of comprehension questions and the inhibition measure did not correlate with any of the two reading measures in either group[42]. For Greek, most of the predictor variables showed significant associations with word decoding and reading comprehension in both groups. Overall, the strength of the correlations was greater in the bilingual data than in the monolingual data in both English and Greek. For the comprehension questions, the lack of a relationship with the reading measures is likely due to ceiling effects[43]. In contrast, the reason for the weak associations with inhibition might be task difficulty. Recall that inhibition was measured in terms of the time it took the children to respond to congruent and incongruent trials. The overall long reaction times (around 1650ms across participants and conditions) and large standard deviations (nearly 750ms across participants and conditions) indicate that at least for some of the children (especially younger ones), task demands might have been too high to reliably measure their inhibition skills. Nevertheless, the fact that most of the other predictor variables showed significant correlations with the reading measures supports the idea that reading is a highly complex process that is composed of many different sub-skills. As anticipated, the three measures derived from the SRT correlated highly with each other in both groups and languages. The association between vocabulary and SRT scores was much higher in the bilinguals than in the monolinguals in both languages. On the basis of the correlational analyses, a composite score for oral language skills that included the three measures from the SRT as well as vocabulary scores was computed for each language.

Contributions of vocabulary, RAN, and verbal WM to word reading in English and Greek across groups

Vocabulary: The results from the regression analyses showed that vocabulary made a significant contribution to word reading, after accounting for age and non-verbal IQ, in the Greek monolingual and in the bilingual group in both English and Greek. However, the effect of vocabulary for the bilinguals in Greek was almost entirely mediated by RAN and verbal WM, while for the Greek monolinguals and the bilinguals in English, vocabulary explained a small amount of variance over and above the other predictor variables. The lack of a significant contribution of vocabulary to decoding skills in English monolingual children goes against the prediction that lexical skills would be more relevant to word reading in languages with

[42] With the exception of a small correlation between scores on comprehension questions tapping factual information and reading comprehension in the Greek monolinguals

[43] Recall that the average scores for the two different types of comprehension questions were above 85% in both groups and languages (see Chapter 3).

inconsistent orthographies compared to languages with consistent orthographies (Suggate et al., 2014; Verhoeven et al., 2011). Moreover, the commonality analyses suggested that the total contribution of vocabulary to decoding was similar in the Greek monolingual group and the bilingual group in English and Greek (19.5–23%). Although the English data suggests that vocabulary plays a more prominent role in bilinguals, the fact that vocabulary is equally important for word reading skills in monolinguals and bilinguals in Greek is contrary to the expectation that oral skills are more crucial for bilingual reading development. Note, however, that the prediction was based on findings pertaining to reading comprehension (Babayiğit, 2015; Droop & Verhoeven, 2003). Thus, it seems that at least for word reading in transparent languages, lexical skills are equally important for monolinguals and bilinguals. Moreover, in the bilinguals, vocabulary and phonological processing skills (i.e., RAN and verbal WM) seem to be more strongly interrelated in their non-dominant language compared to their dominant language which explains why vocabulary did not make an independent contribution in Greek. While the results for English appear to suggest a bigger role of vocabulary in the bilinguals, the absence of an effect of vocabulary in the English monolinguals might be due to ceiling effects. Recall that the vocabulary test was designed for children up to 8;6 years of age, while the children in the current sample were up to 12;7 old. Consequently, the average score for the English monolinguals was fairly high at nearly 87% showing little variation (*SD*: 5.2%). However, similar scores were obtained for the Greek monolinguals on the equivalent vocabulary measure which makes it unlikely that the difference is caused by ceiling effects. In light of the mixed results regarding the predictive role of vocabulary obtained in this and other studies (Bellocchi et al., 2017; Muter et al., 2004; Ouellette, 2006), the issue warrants further investigation.

Rapid automatized naming (RAN): Rapid naming was a significant predictor of word reading skills in English for both groups and in Greek for the monolinguals. However, for the monolinguals the amount of unique and total variance associated with RAN was observed to be slightly higher in Greek, while for the bilinguals, RAN appears to contribute more variance in English. Although the current analyses cannot ascertain whether the observed pattern for the monolinguals reflects a statistically significant interaction between RAN and language, the seemingly larger contribution of RAN in Greek goes against the prediction that there should be no effects of orthographic transparency on the RAN-reading relationship when similar measures of word reading are used across languages (Caravolas et al., 2012a; Vaessen & Blomert, 2010). The observation that RAN shows a stronger association with word reading in Greek is also in contrast to findings from a recent meta-analyses on the RAN-reading relationship which revealed that overall, RAN seems to be more strongly related to word decoding in opaque orthographies than in consistent orthographies (Araujo, Reis, Petersson & Faisca, 2015). While the reversed pattern found in the bilinguals is in support of Araujo et al. (2015), it should be kept in mind that the RAN-reading relationship is likely to change as a function of reading proficiency. More specifically, the results from Araujo et al.'s (2015) meta-analysis indicate that the contribution of RAN to word reading increases until second grade and decreases again thereafter. Thus, it is possible that the pattern observed in the bilinguals (i.e., RAN showing smaller contribution to word reading in Greek) is due to their relatively low proficiency and literacy skills in their minority language. A more systematic investigation of how reading proficiency affects the RAN-reading relationship in monolinguals and bilinguals is needed to confirm this hypothesis. Taken together, the results support previous findings showing that RAN is a useful predictor of accuracy in word reading in both monolingual and bilingual children regardless of orthographic consistency (Ziegler et al., 2010). In addition, the fact that in the bilinguals almost all of the variance explained by RAN was shared with other predictors points to the importance of taking into account the interrelationships between the various subskills, as the effect of RAN might be obscured by common variance.

Verbal WM: The results from the regressions further showed that verbal WM accounted for additional variance in decoding over and above the other predictor variables only in the bilinguals. For the two monolingual groups, verbal WM did not make an independent contribution to word reading which seems add odds with findings by Christopher et al. (2012) and Gottardo et al. (1996) but, it had still had an effect through variance common with other predictor variables. Note that the discrepancy in terms of an independent contribution of verbal WM found in other studies might be due to the specific tasks used. In both Christopher et al. (2012) and Gottardo et al. (1996), verbal working memory was measured by tasks that made much higher demands on language skills than the digit backwards task used here which might explain the stronger direct relationship with word reading reported in these studies. The amount of common variance associated with verbal WM was nearly equal in the two monolingual groups (L1-English: 14.6%; L1-Greek: 14.7%), and very similar across the two languages in the bilinguals (English: 34.6%; Greek: 29.8%). Hence, the prediction that verbal working memory would be more relevant in languages with opaque orthographies is not supported by the monolingual data. The results for the bilinguals do seem to suggest a slightly larger contribution of verbal WM in English in line with Geva and Siegel (2000) on which the prediction was based, but the statistical analyses presented here are not sufficient to support such a claim. Interestingly, the contribution of verbal WM to word decoding was nearly twice as large in the bilinguals compared to their monolingual peers in both languages which is consistent with findings by Bellocchi et al. (2017). Recall that executive functions (including working memory) are argued to be enhanced in bilinguals (Adesope et al., 2010). Thus, one possible explanation for the difference in the relative importance of verbal WM across groups is that bilingual children rely more on their memory skills than monolinguals in order to (at least partly) compensate for weaknesses in other areas, most notably vocabulary (see Hansen et al., 2017, for similar arguments). Further research is needed using different statistical procedures to confirm this hypothesis.

Other predictors of word reading in English and Greek

The subsequent exploratory analyses yielded additional contributions of oral language and executive function skills to word reading, as anticipated, although the observed patterns differed across languages and groups. For Greek, accuracy scores from the SRT was a significant predictor of word reading in the bilinguals. Recall that overall accuracy on the sentence repetition taps into grammatical competence and vocabulary, but also working memory (Riches, 2012). Thus, the fact that accuracy scores on the SRT were associated with word reading in bilinguals is in line with the view that oral skills are particularly important in bilingual reading development (e.g., Proctor et al., 2005; Verhoeven, 1990). For decoding in English monolinguals, scores on the 2-back and the letter fluency task made additional independent contributions to word decoding. Recall that the measure of vocabulary did not contribute to word reading in English monolinguals. However, the letter fluency task taps into both lexical skills and executive control (Shao et al., 2014), thus suggesting that lexical skills in fact did contribute to word decoding in the English monolinguals (in line with Chiappe et al., 2004; Nation & Snowling, 2004; Ouellette, 2006, amongst others). Moreover, the significant contribution of LF in the English monolinguals corroborates previous findings by Messer et al. (2016) showing that measures of verbal fluency are good indicators of word reading skills. Letter fluency did not account for additional variance in the Greek monolinguals and in the bilinguals in either language which is likely due to the moderate correlations between LF scores and vocabulary in these two groups. In contrast, LF scores did not correlate with vocabulary in the English monolinguals which further points to the possibility that the vocabulary measure used in the present study did not adequately capture the lexical skills of the English monolinguals. The fact that the 2-back scores accounted for additional variance in the English monolingual group supports the view that executive function skills that are related to attentional control account for variance in word reading (e.g., Arrington et al., 2014). However, the 2-back scores did not come out as an additional predictor for Greek monolinguals, indicating that updating skills might be less relevant for word decoding in transparent languages, but this does not explain the lack of a contribution in the bilingual data. Finally, there was no evidence for a contribution of inhibition or switching abilities in the current study which is in contrast to findings by Altemeier et al. (2008). In their study, Altemeier et al. (2008) did not include any control variables, such as non-verbal IQ, and the tasks used to measure inhibition and switching included verbal stimuli (i.e., words and letters) which might be the reason for the discrepant findings. Future studies are needed that look into the relationship between EF skills and word reading in monolingual and bilingual learners across different languages to see whether orthographic transparency and language proficiency mediate the relationship between executive control measures and word reading.

Contributions of decoding and oral language skills to reading comprehension in English and Greek across groups

Turning to reading comprehension, age and non-verbal IQ accounted for a considerable amount of variance in all four datasets (between 20-60%). The commonality analyses revealed that the contribution of age was much larger in the Greek monolinguals than in the other two groups which might be due to differences between the English and Greek reading comprehension measures. More specifically, the English measure was designed to cover the whole age range of primary school children so that children with relatively low levels of literacy could still be administered two passages. In contrast, the Greek reading comprehension test was targeted at children from grade 3 onwards, which means that many of the younger monolingual children could only be administered parts of the test. This might explain why scores on the reading comprehension measure in Greek monolinguals were more contingent on age than in English monolinguals.

For the bilinguals in Greek, reading comprehension was largely dependent on oral language skills. Because of the large variation within the bilinguals in terms of exposure patterns to English and Greek, language proficiency is a more important factor for the development of reading comprehension than age. In fact, in the current study, oral language skills were the best predictor of reading ability in bilinguals in either language. In line with previous research (e.g., Chen & Vellutino, 1997; Nation & Snowling, 2004), both decoding and oral language skills were associated with reading comprehension performance in both groups and languages, with the exception of the English monolinguals where decoding skills did not show a significant association with reading comprehension. Although this is consistent with studies showing that the contribution of decoding decreases throughout the primary school years (e.g., Catts et al., 2006; Gough et al., 1996), it is unclear why a similar developmental shift is not visible in the bilinguals in English, given that their reading comprehension was within age-appropriate levels. Moreover, it was predicted that reading comprehension would be more closely related to oral language skills than to decoding abilities, especially in the more transparent orthography of Greek. While this was indeed the case for the bilinguals in both languages, the results for the Greek monolinguals showed similar contributions of oral language and decoding skills. Notably, the large influence of decoding skills on Greek reading comprehension in the bilinguals might be explained by their relatively low language and literacy skills which suggest that they are at an earlier stage in the reading acquisition process than the monolinguals. But, this does not explain why decoding skills still contributed substantially to reading comprehension in the Greek monolinguals, since they can be assumed to be at an equally advanced stage in their literacy development as their English monolingual peers. The most likely explanation for the discrepant findings between the English and Greek monolinguals in terms of the relative contribution of oral language and decoding are task characteristics. It is possible that the multiple-choice format employed in the Greek measure relies more on decoding skills, because the choice of the correct answer typically requires attention to little details and subtle differences in the wording of the passage and the test items. In contrast, the open question format of the reading measure in English requires less attention to details in the exact wording of the information in the passages, so that overall language skills become more important. In any case, the unique variance accounted for by oral language and decoding in the Greek monolinguals was very small (<5%). Moreover, it is notable that the majority of the effect of decoding on reading comprehension in either language of the bilinguals was shared with other variables, especially vocabulary.

As predicted, the effect of oral language skills on reading comprehension was considerably larger in the bilinguals compared to the monolinguals in each language. This corroborates previous studies that also found that oral language skills played a more prominent role in reading comprehension in bilinguals compared to monolinguals (e.g., Babayiğit, 2014; Geva & Farnia, 2011; Verhoeven, 2000). Moreover, the contribution of oral language in the Greek monolinguals was not significant after accounting for individual differences in decoding ability suggesting that oral skills contributed indirectly to reading comprehension via decoding. The commonality analyses further indicated that the overall the amount of variance explained by decoding skills was larger in the bilinguals compared to the monolinguals. This is in contrast to the expectation that decoding would make similar contributions in monolinguals and bilinguals (Verhoeven & van Leeuwe, 2012). For Greek, the difference between groups in terms of the influence of decoding skills on RC scores was relatively small (ML: 31% vs. BL: 41%) and could be explained by the overall lower reading proficiency of the bilinguals. For English, the difference is quite striking with a total contribution of 47% in the bilinguals compared to a mere 4% in the monolinguals. It is likely that the marked difference has multiple sources, such as relatively little variance in the decoding scores for the monolinguals, and more shared variance between oral skills and decoding in the bilinguals.

Other predictors of reading comprehension in English and Greek

In terms of additional contributions of the remaining variables, the regressions revealed that switching accounted for a small amount of unique variance in the bilingual group in English and in the Greek monolinguals. This extends previous findings by Altemeier et al. (2008) who found evidence for a relationship between switching abilities and reading comprehension in English monolinguals from Years 1-5. Altemeier et al. (2008) used switching tasks with a verbal component, (i.e., words and digits) and did not include competitor variables such as verbal and non-verbal IQ in the analyses. In the current study, switching was measured by a task using non-verbal stimuli (i.e., shapes) and was found to contribute to reading comprehension even when age, non-verbal IQ, vocabulary and decoding skills were accounted for. Visuospatial WM accounted for additional variance in Greek reading comprehension in the bilingual group who also showed a small effect of updating skills although its contribution was largely mediated by visuospatial WM. This is in line with previous studies showing significant associations between working memory and reading comprehension in both monolinguals (Arrington et al., 2014; Christopher et al., 2012; Sesma et al., 2009) and bilinguals (Swanson, Orosco, Lussier, Gerber & Guzman-Orth, 2011). Note that verbal WM did not come out as a significant predictor of reading comprehension in any group which is in contrast to findings by Arrington et al. (2014) who used the same type of task to measure verbal WM and reported significant effects of verbal WM on reading skills. However, the authors noted that verbal WM also made a significant indirect contribution to reading via decoding skills. Thus, it is likely that verbal WM did not explain additional variance in the current study because its effect on reading comprehension was mediated by decoding skills. The fact that visual WM contributed to reading comprehension in the bilinguals, but not the monolinguals supports the idea that bilinguals rely more on WM skills to compensate for their lower language proficiency. Finally, the inconsistency across languages in that visual WM was found to predict reading performance in Greek, but not in English might again be due to the different task format of the reading comprehension measures. Verbal WM skills have been assessed through a wide range of tasks and previous studies have typically used a latent variable approach to examine the relationship between WM and reading performance. Thus, future investigations that use multiple measures of verbal and visual WM and equivalent reading tests across languages might produce clearer results.

For the English monolinguals, RAN made a small independent contribution to reading comprehension over and above the other predictor variables. This is in line with findings by Joshi and Aaron (2000a) who also found significant effects of RAN on reading comprehension in English monolinguals (see also, Araujo et al., 2015 but see, Christopher et al., 2012, for different results). However, there was no effect of RAN on reading comprehension in the Greek monolinguals and in the bilinguals. There are several explanations for the discrepant findings. The reading-RAN relationship is affected by the type of reading measure used in that measures of basic reading skills such as word reading accuracy, and measures of reading speed or fluency show much stronger relationships with RAN than measures of reading comprehension (Araujo et al., 2015). For example, Bellocchi et al. (2017) found that RAN predicted reading speed, but not reading comprehension in both monolinguals and bilinguals, with the relationship being stronger for the monolinguals. This suggests that RAN is not a crucial factor when reading is assessed through comprehension using untimed measures. Moreover, studies that found significant relationships between RAN and reading comprehension in bilinguals typically do not control for word reading skills (e.g., Nakamoto, Lindsey & Manis, 2006; Swanson et al., 2011). Hence, it is likely that the effect of RAN on reading comprehension in bilinguals is mediated by decoding skills, which might also be the case for the Greek monolinguals. Finally, the difference in terms of the predictive role of RAN between the English and the Greek monolinguals could again be due task-specifics of the reading comprehension measures. The present results did not provide any evidence for a significant contribution of inhibition skills over and above non-verbal IQ, age, oral language and decoding skills which corroborates findings by Christopher et al. (2012) and Swanson et al. (2011). It has been suggested that inhibition is strongly related to general cognitive ability (Christopher et al., 2012) which would explain why it did not add additional variance to reading comprehension in the current study since non-verbal IQ and other cognitive measures were included in the analyses. In fact, studies that have reported significant effects of inhibition have not controlled for factors such as fluid intelligence in the analyses (Altemeier et al., 2008; Arrington et al., 2014). Moreover, Messer et al. (2016) compared the contribution of verbal and non-verbal EF measures to word decoding and found that only verbal EF measures were related to word reading. Hence, it is possible that the lack of a relationship between inhibition and reading comprehension in the current study is due to the task using non-verbal stimuli. Overall, the results from the regression analyses provide evidence for the importance of executive function skills for reading comprehension as reported in previous studies (Christopher et al., 2012; Sesma et al., 2009). The finding that different measures of EF contributed to reading comprehension across the two groups and languages is difficult to interpret because of the different test formats of the reading comprehension measures. Consequently, more research is needed that compares the contribution of executive functions to reading development in monolingual and bilingual children across different languages.

Unexplained variance

The set of predictors used in the present study were able to account for a large amount of variance in both reading measures. However, it is clear that there is still more variance to explain. For decoding, the predictors accounted for over 70% of the variance in the bilingual group in English, while for the two monolingual groups and the bilinguals in Greek, the total amount of variance explained by the full models was only 42-43%. Following previous research (e.g., Kirby et al., 2008; Melby-Lervåg et al., 2012), phonological awareness would be expected to account for a good amount of the remaining unexplained variance in word reading. Phonological short-term memory is another skill that has been linked to decoding abilities in various languages (e.g., Jong & Leij, 1999; Muter & Snowling, 1998), and some studies also found significant contributions of morphological awareness (Kuo & Anderson, 2006). For reading comprehension, the set of predictors selected for the current study accounted for over

70% of the total variance in the Greek monolinguals and in the bilinguals in both languages. The total amount of variance explained by the full model was considerably lower in the English monolingual sample at 45%. At least for the English monolinguals, it seems that more appropriate measures of oral language skills would lead to a significant improvement of the model. Nation and Snowling (2004) showed that when both measures of vocabulary and listening comprehension skills are included, listening skills come out as the more important factor in predicting reading comprehension. Thus, the use of a more appropriate measure of listening comprehension might further increase the predictive power of the models in the current study. Recent studies also point to the importance of reading fluency (Kershaw & Schatschneider, 2012; Tilstra et al., 2009) which might explain additional variance in reading comprehension over and above the predictors examined here. Moreover, there are several studies that show a link between reading comprehension and higher-order cognitive skills that involve executive control. For example, Oakhill and Cain (2012) found that inferencing skills and comprehension monitoring were significant predictors of reading comprehension in Year 6 students. Finally, there is mounting evidence that narrative abilities are a reliable predictor of literacy development in both monolingual and bilingual populations (Griffin et al., 2004; Miller et al., 2006; Wellman et al., 2011; Wong et al., 2017).

Summary

Taken together, the results for word reading skills show highly similar patterns of predictors across the two groups and languages, but subtle differences in the underlying relationships. The significant contributions of vocabulary and RAN are consistent with previous findings although the absence of a relationship between vocabulary and word reading in the English monolingual sample is puzzling and warrants further research. The most notable difference between the groups was that the bilinguals seem to rely more on verbal WM skills than their monolingual peers in both languages. In contrast, RAN is a better unique predictor of word reading skills in monolinguals compared to the bilinguals since vocabulary and phonological processing skills seemed to be highly conflated constructs in this group. The comparison between the two monolingual groups did not point to any crosslinguistic differences in terms of the importance of the various predictors examined in this study.

In addition, the results showed additional contributions of measures that tapped both verbal and executive function skills (i.e., letter fluency, 2-back, SRT). The results for reading comprehension showed larger contributions of oral language skills in the bilinguals compared to the monolinguals in both English and Greek. Decoding did not contribute to reading comprehension in the English monolinguals, while it had a large effect on reading ability in the bilinguals. This suggests that decoding continues to exert a strong influence on reading comprehension in the bilinguals for longer, although it should be noted that oral skills and decoding show a large degree of overlap in this group. For Greek reading comprehension, oral language was the best unique predictor for the bilinguals, whereas age explained the largest amount of unique variance in the monolinguals. In both groups, decoding and oral language made similar contributions, although there was a lot of overlap with other predictors resulting in relatively small unique effects (except for oral language skills in the bilinguals which contributed 20% of unique variance). The crosslinguistic comparison is difficult because of differences in the task format of the reading comprehension measures. The large effect of age in the Greek monolinguals, together with the marked differences between the two monolingual groups in terms of the relative contributions of oral language and decoding skills point to mediating effects of task characteristics. Overall, the results support the hypothesis that bilinguals rely more on working memory than monolinguals and provide further evidence for the importance of switching abilities for reading comprehension. Finally, the commonality analyses revealed that there was a large amount of overlap between the predictor variables, especially in the bilinguals resulting in relatively small amounts of unique contributions. The large amount of overlap between variables suggests that the order in which the predictors are entered into the regression models has a big impact on the results. Thus, it is recommended that regression analyses are supplemented by an analysis of covariances to better understand the interrelationships among predictor variables.

CHAPTER 5 - BILITERACY & ORACY

5.1 Research questions & hypotheses

The aim of this chapter is to explore the possible contribution of biliteracy to oral language skills in the bilingual children’s majority and minority languages English and Greek. The majority of research on (bi)literacy has focused on the role of oral language skills for reading development. The Simple View of Reading has been most influential in this regard by postulating linguistic comprehension (i.e., oral skills) and word decoding abilities as the two key components of reading comprehension (Hoover & Gough, 1990). While many studies have come to show that oral language skills account for a considerable amount of variance in reading comprehension in both monolinguals (e.g., Nation & Snowling, 2004; Silva & Cain, 2015) and bilinguals (e.g., Babayiğit, 2015; Miller et al., 2006), it is reasonable to assume that the relationship between oral and written language skills is reciprocal (Perfetti, Landi & Oakhill, 2005). Written language is more complex than spoken language in terms of density, lexical diversity and the range of grammatical structures used (O'Donnell, 1974). Thus, reading can be seen as exposure to syntactically more complex language, so that uptake of written language input is hypothesized to foster oral language development. Note that the argument is not that children with higher levels of literacy have better knowledge of grammar, but rather that they have an increased familiarity with more complex grammatical structures. With increasing familiarity, the structures are processed more easily, and are thus, also more likely to be used in production (Ellis, 2002).

Only few studies have directly examined the influence of literacy on oral language skills. Connor et al. (2016) followed 852 children from first to second grade and found evidence for reciprocal effects between semantic knowledge[44] and reading using structural equation modelling and path analyses. The authors argue that semantic knowledge guides scaffolding strategies that are crucial to successful reading comprehension. At the same time, successful comprehension of written text allows children to further extend their semantic knowledge which implies that literacy instruction may have positive effects on oral language skills. Similar reciprocal effects between reading and oral proficiency were found in a large-scale study by Verhoeven et al. (2011) comprising 2790 children. Participants were followed from Grade 1 up until Grade 6 and were assessed on basic and advanced vocabulary as well as decoding and reading comprehension skills at regular intervals. Results showed significant cross-lagged effects between word decoding and vocabulary through Grades 2 to 5, as well reciprocal relations between vocabulary and reading comprehension in the lower grades.

[44] Semantic knowledge was assessed with two assessments from the Woodcock-Johnson III (Woodcock, McGrew & Mather, 2001), an academic knowledge task that required children to answer questions such as *Why do people put money in the bank?*, and a picture vocabulary task where children had to name a series of pictures.

Further evidence for literacy effects on oral language skills comes from studies that use measures of print exposure rather than direct assessments of reading skills. For example, Bitetti and Hammer Scheffner (2016) investigated the role of home literacy environment on Spanish-English bilingual children's narrative skills in English. Home literacy environment was indexed by the frequency of literacy activities and number of children's books at home as reported by the children's mothers. Children were followed from preschool through 1st grade and were assessed on narrative abilities at both micro- and macrostructure levels at 6-month intervals. The results from growth curve modelling showed that the frequency with which mothers read to their children had a positive effect on children's narrative skills at the level of macrostructure. In contrast, there was no evidence for a relationship between home literacy environment and microstructure scores. The authors concluded that frequent book reading helps children internalise the more global macrostructure features of narratives which are to a large degree language-independent. In contrast, the more language-specific microstructure measures, such as mean length of utterance in morphemes (MLU-m) and number of different words (NDW), did not seem to be affected by frequency of book reading or other aspects of the home literacy environment. The results for the microstructure measures are inconsistent with studies that have found a positive impact of book reading on monolingual children's oral language skills, such as narrative skills (Leseman, Scheele, Mayo & Messer, 2007) and vocabulary (see Bus, IJzendoorn & Pellegrini, 1995 for review). However, as Bitetti and Hammer Scheffner (2016) noted, no information was collected on the language, in which these home literacy activities took place (English or Spanish). Hence, the lack of an effect of book reading on narrative abilities at the level of microstructure in English may be due to the literacy activities at home taking place predominantly in Spanish. If this was indeed the case, the findings render support to the idea that the effect of book reading on macrostructure is transferable across languages, while the effect on microstructure is language-specific, so that English microstructure abilities are influenced by book reading activities carried out in English with little or no effect of activities carried out in another language.

Turning to biliteracy, there are two possible ways in which biliteracy could affect oral language skills in the minority and majority language of bilingual children. The first possibility is that biliteracy supports oral language skills through commonalities in higher level processing skills and knowledge that are, at least to some degree, language-invariant (e.g., knowledge of story structure). In this case, biliteracy contributes to oral language skills through experience with written text accumulated across the two languages. Alternatively, it is conceivable that biliteracy affects oral skills via executive function abilities. The rational for this possibility is that biliteracy leads to superior executive function skills because the acquisition of literacy in a given language results in an additional level of representation in the brain (orthographic representation) which, in turn, increases the activation level of that language. A high level of (simultaneous) activation of two languages gives rise to higher levels of between-language competition, and thus, requires more cognitive control to manage communication demands. In this scenario, it is not only the actual level of literacy in each language that is relevant, but also the degree to which literacy skills are balanced across languages. There has been little research on biliteracy and its effects on language and cognitive skills and there is no commonly used measure of biliteracy. In the present study, biliteracy was computed in two ways: based on amount of formal schooling in the two languages (BIS=biliteracy index schooling) and based on children's performance on a single word reading task in English and Greek (BIR=biliteracy index reading). Moreover, two different formulae were applied resulting in four different indices in total (BIS1&2 and BIR1&2, see section 2.4). The set of indices based on amount of schooling reflect a child's *experience* with literacy instruction in the two languages in the school context, while the indices based on word reading skills indicate a child's reading *proficiency*. Moreover, the two formulae that were used differ in terms of the weight that is given to two factors: *balance* and *actual level* of experience or proficiency. Consequently, BIS/BIR1 are purely relative measures with no information on the children's actual amount of schooling or level of proficiency (i.e., balance), while BIS/BIR2 can be seen as indices of children's actual levels of biliteracy (i.e., average level of literacy across the two languages). BIS/BIR1 are essentially difference scores, which means that a score of 0 would indicate perfect balance. Thus, the expectation is that lower scores on the BIS1/BIR1 and higher scores on the BIS2/BIR2 will be associated with overall better performance on the oral language measures. The specific research questions addressed in this chapter are:

i. *Do measures of biliteracy explain additional variance in performance on the Sentence Repetition Task after controlling for age, non-verbal IQ, vocabulary, and bilingual input at home?*

Previous studies have shown that performance on sentence repetition tasks is linked to reading outcomes (e.g., Alloway & Gathercole, 2005; Babayiğit, 2015). Moreover, there is evidence that story-reading-aloud to children has positive effects on oral language skills, as measured by sentence imitation and comprehension of stories (Vivas, 1996). No studies to date have looked at the effects of (bi)literacy on sentence repetition, so predictions can only be tentative. In order to repeat a sentence verbatim, children need to be familiar with the relevant target vocabulary and have acquired the relevant target structure, i.e., they need to have the required grammatical competence. Moreover, sentence imitation taps working memory skills because semantic information needs to be integrated with structural cues, while, at the same time, keeping the whole sentence in memory for subsequent recall (Alloway & Gathercole, 2005). The linguistic requirements of the SRT are highly language-specific hence, no significant contribution of biliteracy is predicted for grammaticality or structure scores. In contrast, a positive effect of biliteracy might emerge for overall accuracy scores as they are partly dependent on working memory skills which might be enhanced by biliteracy.

ii. *Do measures of biliteracy explain additional variance in listening comprehension after controlling for age, non-verbal IQ, vocabulary and bilingual input at home?*

According to the SVR, linguistic comprehension is one of two key component skills underlying reading comprehension and there is ample research in support of this (e.g., Babayiğit, 2014; Gough et al., 1996; Roth et al., 2002). Only few studies have looked at effects in the opposite direction, i.e., from literacy to linguistic comprehension. Verhoeven and Leeuwe (2008) found reciprocal associations between listening and reading comprehension in a large sample of school-aged children suggesting that both types of comprehension rely on the same underlying language skills (see also Sears & Keogh, 1993). Like sentence imitation, listening comprehension depends heavily on language-specific lexical and grammatical skills. Thus, there is little reason to expect a significant contribution of biliteracy to listening comprehension skills. However, in the current study, listening comprehension was measured by means of narratives, which means that knowledge of story structure could have a positive effect on comprehension scores. Vivas (1996) found evidence that frequent story-book reading improved children's story comprehension skills. Hence, any significant contributions of biliteracy to listening comprehension scores are likely to be due to children's knowledge of story structure which is language-invariant, and therefore, transferable across languages. Another possibility is that biliteracy affects narrative comprehension via executive function skills. In this case, a significant association would be expected between biliteracy and questions about the mental states of characters, but not necessarily between biliteracy and factual questions. This is because, questions that refer to the mental states of characters tap skills that are related to Theory of Mind skills (e.g., making inferences about emotions) which are closely linked with executive function abilities (Carlson & Moses, 2001; Hughes, 1998).

iii. *Do measures of biliteracy explain additional variance in narrative skills at the level of microstructure after controlling for age, non-verbal IQ, vocabulary and bilingual input at home?*

Recall that narrative abilities can be analysed at the level of macrostructure and microstructure. Macrostructure refers to the overall coherence and organization of the story while microstructure is concerned with linguistic features of narratives at the word and sentence level such as length, syntactic complexity and lexical diversity, among others. Narrative skills at the level of macrostructure require knowledge about story grammar in terms of introducing characters, establishing the setting and describing complete story episodes that consist of causally connected goal-attempt-outcome sequences (Trabasso & Nickels, 1992). Story structure taps knowledge and skills that are to a large degree language-invariant, and thus, relatively independent of a child's level of language proficiency. In contrast, narrative abilities at the level of microstructure predominantly tap lexical and syntactic skills that are highly language-specific. Moreover, the quality of a story depends at least to some extent on executive function abilities in that the narrator needs to maintain the overall story structure in memory, while giving complete and coherent accounts of the smaller story segments and shifting between one episode and the next (Friend & Bates, 2014). In support of this, Friend and Bates (2014) found that that EF skills and narrative production were related longitudinally but not concomitantly in monolingual 4 to 5-year-old children. Narrative production was measured in terms of a complexity scale developed by Cobo-Lewis et al. (2002a) that included both microstructure and macrostructure features, so it remains unclear how EF skills relate to each of the two levels of narrative skills individually. Turning to the predictions for the present sample, if biliteracy has positive effects on executive function skills, it is in principal possible that the data show an association between biliteracy and microstructure measures. However, the relative importance of EF skills for narrative microstructure is likely to be rather small compared to language proficiency. Hence, it is predicted that biliteracy will make no significant contribution to narrative microstructure skills. This is because measures of story length, syntactic complexity, grammaticality, and verb diversity are heavily dependent on language proficiency, especially vocabulary and syntactic skills and are thus, highly unlikely to be transferable across languages (Iluz-Cohen & Walters, 2012).

5.2 Data analyses

The research questions were addressed by running a series of fixed-order hierarchical regressions. Before running the regression analyses, bivariate correlations were calculated to locate significant associations between the predictor variables and the outcome measures, and to identify potential issues with multicollinearity among the predictor variables. For the regressions, a baseline model was specified first, to which the various biliteracy indices were added in an additional step to examine whether biliteracy makes a unique contribution to children's oral language skills in the two languages. The baseline model included the following variables: 1) age; 2) non-verbal IQ, i.e., Raven's standard scores; 3) bilingual input at home and, 4) vocabulary scores in the respective language. Bilingual input at home was calculated as the difference between English and Greek in terms of relative amount of language input/use at home (see section 2.2.2), and was included in order to disentangle bilingualism effects from biliteracy effects. In the baseline models, vocabulary was entered separately at a second step in order to determine its independent contribution to the outcome measures. Each regression model was assessed as to whether the assumptions for multiple linear regressions were met. Outliers were identified by looking at the standardized residuals where values of >3.29 represent outliers. Moreover, the data was scanned for influential cases, i.e., data points for which Cook's Distance exceeded 1. The assumption of independence of errors was checked by inspecting the Durbin-Watson test statistic where values below 1 and above 3 have been suggested to be cause for concern. Homoscedasticity was assessed by plotting the standardized predicted values against the standardized residuals and inspecting the resulting graph for violations of homogeneity of variance and/or violations of the assumption of linearity. Finally, multicollinearity was gauged by inspecting the values for the variance inflation factor (VIF) statistic which is an indication of the strength of the relationship between predictors. Models that contained VIF values above 10 or for which the average VIF was substantially greater than 1 were flagged and were reported as unreliable.

5.3 Results: Correlations

The correlations coefficients (Pearson's *r*) for the associations between the predictor variables and the outcome measures in English and Greek are given in Tables 39 and 40, respectively. For English, the results showed strong correlations among the three SRT measures (*r*s between .808 and .872, all *p*s<.001), while scores for the two types of comprehension questions (i.e., questions about factual information and questions tapping mental states of characters) were only weakly correlated ($r(50)=.339$, $p=.018$). For microstructure measures, story length showed a positive association with syntactic complexity ($r(50)=.653$, $p<.001$), whereas verb diversity was negatively correlated with length $r(50)=-618$, $p<.001$), and syntactic complexity ($r(50)=-.423$, $p=002$). The three SRT scores correlated negatively with story grammaticality (*r*s between -.594 and -.604, all *p*s<.001), and SRT accuracy also correlated with story length ($r(50)=.337$, $p=.017$). From the predictor variables, age was positively correlated with story length ($r(50)=.430$, $p=.002$), syntactic complexity ($r(50)=.454$, $p<.001$), and showed a negative correlation with verb diversity ($r(50)=-.299$, $p=.035$). Non-verbal IQ correlated with the three measures from the SRT (*r*s ranging from .343 to .373, all *p*s<.015), while bilingualism at home (i.e., balanced input) did not show any significant associations with any of the outcome variables. English vocabulary was strongly correlated with the three measures from the SRT (*r*s ranging from .591 to .657, all *p*s<.001), as well as with the grammaticality index from the narratives ($r(50)=-.588$, $p<.001$). Regarding the four biliteracy indices, BIS1 did not correlate with any of the oral language measures. In contrast, BIS2 showed significant positive correlations with story length and syntactic complexity (length: $r(48)=.348$, $p=.015$, and complexity: $r(50)=.390$, $p=.006$), as well as a marginally significant negative association with grammaticality scores from the narratives ($r(50)=-.274$, $p=.059$). BIR1 correlated negatively with syntactic complexity ($r(50)=-.361$, $p=.010$), and showed a marginally significant negative association with comprehension questions about mental states of characters (r=-.255, p=.074). Finally, BIR2 scores showed significant positive associations with story length (r(50)=.368, p=.009) and syntactic complexity (r(50)=.414, p=.003), while the association with mental state questions was only marginally significant (r(50)=.238, p=.096).

Turning to Greek, the three SRT measures were again highly correlated (rs between .848 and .888, all ps<.001), and there was a moderate association between the two comprehension question types (r(50)=.427, p=.002). The narrative measures showed moderate to strong associations with each other and with SRT scores (rs between -.479 and .887, all ps<.001), with the exception of the verb diversity measure which only correlated with story grammaticality (r(50)=-.393, p<.005). Moreover, grammaticality of the narratives and scores on the comprehension questions about factual information showed a small negative correlation (r(50)=-.335, p=.017). Regarding the relationships between the predictor variables and the Greek outcome measures, age showed a strong correlation with syntactic complexity of the narratives (r(50)=.539, p<.001), and moderate correlations with SRT accuracy and grammaticality scores, as well as grammaticality, length and number of different verbs in the narratives (rs ranging from .336 to -.365, all ps<.019). Non-verbal IQ and bilingualism at home did not correlate with any of the oral language measures in Greek. Greek vocabulary showed strong correlations with all measures from the SRT and the narratives (rs ranging from .500 to .833, all ps<.001), except for the correlation with verb diversity which was considerably smaller, but still significant (r(50)=.305, p=.031). For the four biliteracy indices, BIS1 did not correlate with any of the oral language measures, while BIS2 showed a significant positive association with narrative length (r(50)=.300, p=.038), and a negative association with scores on mental comprehension questions (r(50)=-.452, p<.001). For the performance-based indices, BIR1 showed a significant negative association with SRT accuracy scores (r(50)=-.366, p=.010), as well as a positive association with story grammaticality (r(50)=.312, p=.027). Moreover, BIR1 showed marginally significant correlations with SRT grammaticality scores, scores for factual comprehension questions, story length and syntactic complexity (rs between -.244 and -.273, all ps<.10). Finally, BIR2 was positively correlated with SRT accuracy, SRT grammaticality, story length, and syntactic complexity of the stories, and showed a negative association with story grammaticality (rs between -.318 and .414, all ps<.024).

Table 39. *Correlations between predictor variables and the oral language measures for English.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. SRT-accuracy	--									
2. SRT-grammaticality	.836***	--								
3. SRT-structure	.872***	.808***	--							
4. CQ total	-.060	-.098	-.154	--						
5. CQ factual	-.174	-.220	-.279*	.759***	--					
6. CQ mental	.045	.026	-.011	.870***	.339*	--				
7. Story-length	.337*	.143	.221	.181	.092	.194	--			
8. Story-grammaticality	-.598***	-.590***	-.604***	.051	.040	.043	-.245†	--		
9. Story-syntactic complexity	.268†	.055	.108	.183	.060	.221	.653***	-.200	--	
10. Story-verb diversity	.001	.236†	.043	-.226	-.181	-.190	-.618***	.044	-.423**	--
Age	.015	-.223	-.113	.034	.055	.007	.430**	-.051	.454***	-.299*
Non-verbal IQ	.343*	.363**	.373**	.087	-.105	.206	.083	-.251†	.131	.166
Bilingualism at home	-.103	-.207	-.262†	-.032	-.025	-.026	-.030	.241†	.059	-.142
Vocabulary	.620***	.657***	.591***	-.020	-.162	.094	.250†	-.588***	.147	.138
BIS1	-.105	.021	-.178	-.112	-.050	-.123	.033	-.051	-.056	.040
BIS2	.200	.043	.141	-.109	-.097	-.083	.348*	-.274†	.390**	-.183
BIR1	-.193	-.072	-.083	-.227	-.096	-.255†	-.214	.079	-.361**	.091
BIR2	.131	-.024	.018	.215	.097	.238†	.283*	-.078	.343*	-.178

Note. SRT = Sentence Repetition task; CQ = comprehension questions; BIS = biliteracy index schooling; BIR = biliteracy index reading
† p<.10; * p<.05; ** p<.01; *** p<.001

Table 40. *Correlations between predictor variables and the oral language measures for Greek.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. SRT-accuracy	--									
2. SRT-grammaticality	.888***	--								
3. SRT-structure	.848***	.859***	--							
4. CQ total	.179	.227	.207	--						
5. CQ factual	.149	.238	.100	.704***	--					
6. CQ mental	.211	.220	.272†	.845***	.427**	--				
7. Story-length	.436**	.374**	.403**	.158	.073	.176	--			
8. Story-grammaticality	-.773***	-.887***	-.860***	-.369**	-.335*	-.286	-.479***	--		
9. Story-syntactic complexity	.584***	.527***	.529***	.125	.073	.127	.636***	-.624***	--	
10. Story-verb diversity	.230	.254†	.213	-.043	.032	-.028	-.241†	-.393**	.077	--
Age	.336*	.346*	.198	-.095	.045	-.277†	.362**	-.365**	.539***	.071
Non-verbal IQ	-.124	-.132	-.174	.121	.163	-.033	.060	.029	-.105	-.097
Bilingualism at home	.196	.030	.032	-.118	.027	-.124	.084	.097	.106	-.019
Vocabulary	.833***	.689***	.729***	.231	.199	.246†	.500***	-.669***	.529***	.305*
BIS1	-.198	-.155	-.130	-.028	-.011	-.084	-.063	.237	-.114	-.203
BIS2	-.042	-.109	-.186	-.242†	-.049	-.452**	.300*	-.048	.210	.002
BIR1	-.366**	-.273†	-.154	-.206	-.244†	-.064	-.267†	.312*	-.262†	-.186
BIR2	.386**	.334*	.143	.117	.224	-.051	.368**	-.318*	.414**	.085

Note. SRT = Sentence Repetition task; CQ = comprehension questions; BIS = biliteracy index schooling; BIR = biliteracy index reading
† p<.10; * p<.05; ** p<.01; *** p<.001

The zero order correlations (Pearson's *r*) for the associations between the predictor variables are presented in Table 41. Age showed moderate associations with Greek vocabulary and the two BIR scores (*r*s between -.301 and .492, all *p*s<.034). Age was also strongly correlated with BIS2 scores ($r(48)=.697$, $p<.001$). Non-verbal IQ was positively correlated with English vocabulary scores ($r(50)=.494$, $p<.001$), but did not correlate with any of the biliteracy indices. Balanced use of the two languages at home (i.e., bilingualism at home) showed moderate positive associations with the biliteracy indices based on schooling (i.e., BIS1 and BIS2), as well as with BIR2 scores (*r*s ranging from .321 to .383, all *p*s<.026). English vocabulary scores did not correlate with any of the indices, except for a small, marginally significant association with BIS2 scores ($r(48)=.277$, $p=.057$). In contrast, Greek vocabulary scores significantly correlated with the two performance-based indices (BIR1: $r(50)=-.279$, $p=.050$; BIR2: $r(50)=.320$, $p=.023$), and showed a marginally significant association with BIS1 scores ($r(48)=-.241$, $p=.098$). With regard to the relationships between the four biliteracy indices, BIS1 did not correlate with BIS2 scores ($r(48)=.092$, $p=.533$), but showed a marginally significant association with BIR1 scores ($r(48)=.279$, $p=.055$). The two biliteracy indices that were calculated on the basis of children's performance on the decoding measure were highly correlated with each other ($r(50)=-.901$, $p<.001$). Finally, there was a small correlation between BIS2 and BIR2 scores ($r(48)=.370$, $p=.010$). Taken together, the correlation analyses show little signs of multicollinearity, with the exception of the strong correlation between age and BIS2 scores, suggesting that the results for BIS2 should be supplemented by further collinearity diagnostics.

Table 41. *Correlations between predictor variables.*

	1.	2.	3.	4.	5.	6.	7.	8.
1. age	--							
2. non-verbal IQ	-.158	--						
3. BL at home	.250†	-.067	--					
4. English vocab	-.007	.494***	-.137	--				
5. Greek vocab	.379**	-.040	.256†	-.316*	--			
6. BIS1	-.115	-.013	.383**	.002	-.241†	--		
7. BIS2	.697***	-.030	.326*	.277†	.165	.092	--	
8. BIR1	-.301*	-.271†	-.176	-.077	-.279*	.279†	-.226	--
9. BIR2	.492***	.261†	.321*	.078	.320*	-.172	.370**	-.901***

Note. BL = bilingualism; vocab = vocabulary

† $p<.10$; * $p<.05$; ** $p<.01$; *** $p<.001$

5.3 Results: Sentence repetition

5.3.1 English

The baseline regression models for the three scores from the sentence repetition task in English are presented in Table 42. The model for SRT accuracy provided a good fit for the data

(F(4,43)=7.13, p<.001) accounting for 39.9% of the total variance. Vocabulary was the only significant predictor (β=.59, p<.001) with an individual contribution of 24.7% to SRT accuracy scores. The baseline model for the grammaticality scores was significant (F(4,43)=10.50, p<.001) and explained 49.4% of the total variance. Vocabulary was the only significant predictor in the model (β=.63, p<.001) individually accounting for 27.7% of the total variance. For SRT structure scores, the baseline model fitted the data well (F(4,43)=7.10, p<.001) and accounted for 39.8% of the total variance. Vocabulary was again the only significant predictor in the final model (β=.50, p<.001) with an individual contribution of 17.8% to the total variance. The contribution of biliteracy to SRT scores was assessed by adding the various biliteracy indices to the baseline regression models to see whether they led to a significant improvement of the model. The results for the final regression models are given in Table 43. None of the four biliteracy indices made a significant independent contribution to accuracy, grammaticality or structure scores from the SRT in English.

Table 42. *Baseline regression models for SRT scores in English.*

	SRT-accuracy			SRT-grammaticality			SRT-structure		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	57.89	10.73		78.88	9.07		77.09	8.06	
1. Age	.01	.06	.02	-.10	.05	-.21†	-.02	.05	-.06
1. Non-verbal IQ	.04	.08	.06	.02	.07	.04	.05	.06	.12
1. BL at home	-.01	.03	-.02	-.02	.03	-.07	-.03	.03	-.17
2. Vocabulary	.71	.17	.59***	.69	.14	.63***	.45	.13	.50***
ΔR^2 Model 2		.247			.277			.178	
F_{Change}		17.65***			23.52***			12.74***	
R^2 Model 2		.399			.494			.398	
F		7.13***			10.50***			7.10***	

Table 43. *Contribution of the four biliteracy indices in the final regression models for English SRT scores.*

	SRT-accuracy			SRT-grammaticality			SRT-structure		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.410	.011	0.80	.495	.001	0.04	.415	.018	1.28
BIS2	.402	.003	0.20	.498	.004	0.38	.427	.029	2.13
BIR1	.416	.017	1.23	.502	.008	0.69	.402	.004	0.27
BIR2	.404	.005	0.35	.496	.002	0.15	.399	.001	0.07

5.3.2 Greek

Table 44 presents the baseline regression models for the three scores from the SRT in Greek. The model for overall accuracy fitted the data well (F(4,41)=23.80, p<.001) and accounted for 69.9% of the total variance. Vocabulary was the only significant predictor (β=.81, p<.001) individually accounting for 54.2% of the total variance. For the grammaticality score, the model was again significant ($F(4,41)=11.58$, $p<.001$) and explained 53% of the total variance. Vocabulary was the only significant predictor ($\beta=.70$, $p<.001$), although the contribution of balanced input at home (Bilingualism at home) just missed significance[45] ($\beta=-.21$, $p=.051$). Similar results were obtained for structure scores. The overall model provided a good fit for the data ($F(4,41)=13.98$, $p<.001$) accounting for 57.7% of the total variance. The only predictor that reached significance was again vocabulary ($\beta=.78$, $p<.001$) accounting for 50.6% of the total variance, while bilingualism at home was a marginally significant predictor ($\beta=-.21$, $p=.061$). The next step was to add the four biliteracy indices to the baseline models to probe whether they made a significant contribution to SRT scores in Greek. Table 45 presents the results for the final regression models for the Greek SRT scores. For overall accuracy scores, both performance-based indices of biliteracy were able to explain a small, but significant amount of additional variance over and above the variables included in the baseline model (BIR1: $F(1,40)=7.27$, $p=.010$; BIR2: $F(1,40)=8.20$, $p=.007$). The amount of additional variance explained was slightly higher for BIR2 at 5.1%, while BIR1 individually accounted for 4.6% of the variance. Moreover, the results for SRT grammaticality scores showed a marginally significant contribution of BIR2 ($F(1,40)=3.61$, $p=.065$), explaining 3.9% of the total variance. The results further showed significant contributions of BIS2 scores to SRT accuracy ($F(1,40)=5.62$, $p=.023$), SRT grammaticality ($F(1,40)=7.06$, $p=.011$), as well as to SRT structure scores ($F(1,40)=4.80$, $p=.034$). The amount of additional variance explained by BIS2 was 3.7% for accuracy, 7% for grammaticality, and 4.5% for structure scores. However, in all three cases the regression coefficient for BIS2 was negative suggesting that children with lower amounts of formal schooling across the two languages performed better than children who had received high amounts of instruction across the two languages. Recall that BIS2 and age showed a high correlation pointing to possible issues with multicollinearity. However, the associated VIF values were below 2.3, which is well within the acceptable range suggesting that the results were not affected by multicollinearity. None of the other biliteracy indices were able to explain additional variance on structure scores in Greek after accounting for age, non-verbal IQ, bilingual input at home and vocabulary.

[45] Recall that balanced input at home was calculated as the difference in the relative amount of input between English and Greek. Hence, lower scores indicate small differences in amount of input so that children with more balanced input scored higher on grammaticality in the SRT in Greek than children with marked differences in amount of input.

Table 44. *Baseline regression models for SRT scores in Greek.*

	SRT-accuracy			SRT-grammaticality			SRT-structure		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	-12.46	26.61		34.53	20.76		54.72	27.26	
1. Age	-12.17	.16	.10	.17	.12	.16	-.05	.17	-.03
1. Non-verbal IQ	-.13	.16	-.07	-.06	.13	-.05	-.21	.16	-.13
1. BL at home	-.07	.08	-.08	-.13	.06	$-.23^{\dagger}$	-.16	.08	$-.21^{\dagger}$
2. Vocabulary	2.32	.27	$.81^{***}$	1.25	.21	$.70^{***}$	1.94	.28	$.78^{***}$
ΔR^2 Model 2	.542			.402			.506		
F_{Change}	73.83^{***}			35.06^{***}			49.04^{***}		
R^2 Model 2	.699			.530			.577		
F	23.80^{***}			11.58^{***}			13.98^{***}		

Table 45. *Contribution of the various biliteracy indices in the final regression models for Greek SRT scores.*

	SRT-accuracy			SRT-grammaticality			SRT-structure		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.700	.001	0.13	.535	.004	0.37	.585	.008	0.75
BIS2	.736	.037	5.62^{*}	.601	.070	7.06^{*}	.622	.045	4.80^{*}
BIR1	.745	.046	7.27^{**}	.547	.017	1.47	.579	.002	0.20
BIR2	.750	.051	8.20^{**}	.569	.039	$3.61^{\dagger}$	.579	.002	0.21

5.4 Results: Listening comprehension

5.4.1 English

Table 46 presents the baseline models for the total scores on the English comprehension questions, as well as for the scores for questions tapping factual information and questions about mental states of characters separately. The baseline models did not provide a good fit for the data for any of the comprehension question scores (CQ-total: $F(4,43)=0.35$, $p=.841$; CQ-factual: $F(4,43)=0.39$, $p=.816$; CQ-mental: $F(4,43)=0.71$, $p=.590$). Accordingly, neither vocabulary nor the other control variables came out as significant predictors for scores on comprehension questions in English. Table 47 shows the results from the final regression models that included the various biliteracy indices. None of the four biliteracy indices made a significant contribution to any of the English comprehension question scores.

Table 46. *Baseline regression models for scores on the English comprehension questions.*

	CQ-total			CQ-factual			CQ-mental		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	85.53	10.62		98.55	11.45		73.30	14.02	
1. Age	.02	.06	.04	.02	.07	.06	.01	.08	.02
1. Non-verbal IQ	.09	.08	.20	.01	.09	.03	.16	.10	.27
1. BL at home	-.01	.03	-.05	-.01	.04	-.06	-.01	.04	-.02
2. Vocabulary	-.13	.17	-.14	-.20	.18	-.20	-.07	.22	-.05
ΔR^2 Model 2		.013			.027			.002	
F_{Change}		0.60			1.20			0.09	
R^2 Model 2		.032			.035			.062	
F		0.35			0.39			0.71	

Table 47. *Contribution of the four biliteracy indices in the final regression models for the English comprehension question scores.*

	CQ-total			CQ-factual			CQ-mental		
Index	R^2	ΔR^2	*F*	R^2	ΔR^2	*F*	R^2	ΔR^2	*F*
BIS1	.041	.009	0.42	.035	<.001	0.02	.077	.015	0.69
BIS2	.048	.016	0.70	.045	.010	0.42	.073	.011	0.51
BIR1	.069	.037	1.68	.048	.014	0.60	.098	.036	1.68
BIR2	.071	.039	1.79	.050	.015	0.68	.099	.037	1.73

5.4.2 Greek

The baseline regression models for total scores on the comprehension questions and for scores on the two different question types are given in Table 48. For overall accuracy on the comprehension questions, the baseline model accounted for 16.2% of the total variance, but the change in R^2 from the null model was not significant ($F(4,43)=2.07$, $p=.101$). Nevertheless, vocabulary was a significant predictor (β=.38, $p=.019$) that independently explained 11.6% of the total variance. The baseline model for scores on questions probing factual information, the baseline model did not provide a good fit for the data ($F(4,43)=0.99$, $p=.422$) with merely 8.4% of the total variance explained and none of the predictor variables turning out significant. In contrast, the baseline model for comprehension questions about mental states of the characters fitted the data well ($F(4,43)=4.48$, $p=.004$) and accounted for 29.4% of the total variance. Age was a significant predictor (β=-.48, $p=.002$), however, its impact was negative in that younger children scored better on comprehension questions about the mental states of characters than older children. The second significant predictor in the baseline model was vocabulary (β=.49, $p<.001$) which independently accounted for 19.2% of the total variance in comprehension scores probing mental states of characters. A summary of the final regression models that included the four biliteracy indices is given in Table 49. None of the six biliteracy indices was able to explain additional variance in comprehension question scores, with the exception of

BIS2 which made a marginally significant contribution to scores on mental states questions ($F(1,42)=3.29$, $p=.077$), explaining 5.1% of the total variance. Note that all values for VIF were below 2.4 suggesting that multicollinearity was not an issue.

Table 48. *Baseline regression models for scores on the Greek comprehension questions.*

	CQ-total			CQ-factual			CQ-mental		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	81.03	16.08		68.27	17.54		114.77	19.90	
1. Age	-.15	.10	-.23	-.03	.11	-.04	-.42	.12	-.48**
1. Non-verbal IQ	.12	.10	.16	-.01	.05	-.01	-.01	.13	-.01
1. BL at home	-.05	.05	-.15	.24	.17	.24	-.06	.06	-.13
2. Vocabulary	.38	.16	.38*	.16	.11	.21	.66	.19	.49***
ΔR^2 Model 2		.116			.044			.192	
F_{Change}		5.95*			2.09			11.67***	
R^2 Model 2		.162			.084			.294	
F		2.07			0.99			4.48**	

Table 49. *Contribution of the four biliteracy indices in the final regression models for the Greek comprehension question scores.*

	CQ-total			CQ-factual			CQ-mental		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.174	.013	0.64	.087	.003	0.13	.295	.001	0.06
BIS2	.180	.019	0.95	.089	.005	0.23	.345	.051	3.29†
BIR1	.186	.024	1.25	.105	.020	0.95	.304	.010	0.61
BIR2	.175	.013	0.67	.102	.017	0.82	.299	.005	0.29

5.5 Results: Narrative microstructure

5.5.1 English

The baseline models for narrative length and syntactic complexity are given in Table 50 and the models for grammaticality and verb diversity are presented in Table 51. For story length, the baseline model fitted the data well ($F(4,43)=3.63$, $p=.012$), accounting for 25.3% of the total variance. Age was the only variable that came out as a significant predictor (β=.45, $p=.002$) with older children producing longer narratives. The analyses for syntactic complexity yielded similar findings. The baseline model was significant ($F(4,43)=3.59$, $p=.013$) and accounted for 25% of the total variance with age being the only significant predictor in the model (β=.48, $p<.001$). The baseline model for grammaticality provided a good fit for the data ($F(4,43)=6.57$, $p<.001$), explaining 37.9% of the total variance. Vocabulary was the only significant predictor (β=-.57, $p<.001$) and individually accounted for 22.6% of the total variance. The negative value of the regression coefficient reflects the fact that children with larger vocabularies produced fewer grammatical errors in their narratives. For the verb diversity measure, the baseline model did not provide a good fit for the data ($F(4,43)=1.31$, $p=.283$), with only 10.8% of the total variance explained and none of the predictor variables making a significant contribution[46]. The next step was again to add the various biliteracy indices to the baseline regression models to investigate whether they explain additional variance in narrative microstructure. The final regression models for story length and syntactic complexity are given in Table 52 and the models for grammaticality and verb are summarized in Table 53. The results from the final regression models showed no significant contribution of biliteracy to any of the microstructure measures from the English narratives.

Table 50. *Baseline regression models for length and syntactic complexity of the English narratives.*

	Length			**Complexity**		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	-17.52	20.62		-12.96	14.06	
1. Age	.39	.12	$.45^{**}$	.29	.08	$.48^{***}$
1. Non-verbal IQ	.13	.15	.13	.10	.11	.16
1. Bilingualism at home	-.05	.06	-.11	-.01	.04	-.04
2. Vocabulary	.35	.33	.17	.09	.22	.07
ΔR^2 Model 2		.021			.003	
F_{Change}		1.19			0.18	
R^2 Model 2		.253			.250	
F		3.63^{*}			3.59^{*}	

46 Note that age came out as a marginally significant predictor in the baseline model (β=-.27, $p=.078$), although the negative value of the regression coefficient suggests that younger children had higher scores for verb diversity. However, younger children also produced shorter narratives and shorter narratives tended to show more verb diversity. Thus, the negative contribution of age is likely due to the fact that the verb diversity measure is confounded with narrative length. In line with this, the effect of age disappeared when story length was included as an additional predictor in the baseline model (β=.05, $p=.722$).

Table 51. *Baseline regression models for grammaticality and verb diversity of the English narratives.*

	Grammaticality			Verb Diversity		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	32.46	10.57		63.00	11.28	
1. Age	-.04	.06	-.09	-.12	.07	-.27
1. Non-verbal IQ	<.01	.08	.01	.02	.08	.03
1. Bilingualism at home	.05	.03	.19	-.01	.03	-.06
2. Vocabulary	-.66	.17	$-.57^{***}$	.13	.18	.12
ΔR^2 Model 2		.226			.010	
F_{Change}		15.65^{***}			0.50	
R^2 Model 2		.379			.108	
F		6.57^{***}			1.31	

Table 52. *Contribution of the four biliteracy indices in the final regression models for story length and syntactic complexity of the English narratives.*

	Length			Complexity		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.273	.020	1.18	.251	.001	0.02
BIS2	.255	.002	0.12	.258	.008	0.47
BIR1	.257	.004	0.23	.286	.036	2.14
BIR2	.256	.003	0.20	.257	.007	0.41

Table 53. *Contribution of the four biliteracy indices in the final regression models for grammaticality and verb diversity of the English narratives.*

	Grammaticality			Verb Diversity		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.401	.022	1.51	.109	.001	0.06
BIS2	.415	.036	2.59	.109	<.001	0.01
BIR1	.382	.003	0.19	.109	.001	0.05
BIR2	.384	.004	0.30	.113	.004	0.20

5.5.2 Greek

The baseline models for the Greek microstructure measures of story length and syntactic complexity are presented in Table 54, and the models for grammaticality and verb diversity are given in Table 55. For narrative length in Greek, the baseline model provided a good fit for the data ($F(4,43)=5.26$, $p=.002$), explaining 32.8% of the total variance. Vocabulary was the only significant predictor (β=.48, $p<.001$) with an independent contribution of 18.4% to the total variance. The baseline model for syntactic complexity was significant ($F(4,43)=7.62$, $p<.001$), and was able to explain 41.5% of the total variance. The variables that came out as significant predictors were age (β=.40, p=.003) and vocabulary (β=.39, p=.005), with vocabulary making and independent contribution of 12% to the total variance. The narratives of older children and children with higher vocabulary scores were syntactically more complex than the stories produced by younger children and children with low vocabulary scores in Greek. For the measure of grammaticality, the baseline model was again significant ($F(4,43)=12.61$, $p<.001$), and accounted for 54% of the total variance. Balanced input at home and vocabulary came out as significant predictors in the final baseline model, with the contribution of vocabulary being larger (β=-.68, $p<.001$) than that of balanced input at home (β=.31, p=.007). Note that bilingual input at home made a positive contribution to grammaticality scores in that children with more balanced input at home also produced fewer grammatical errors in their narratives. The independent contribution of vocabulary to grammaticality scores in Greek was 37.2%. Turning to the measure of verb diversity, the final baseline model accounted for 10.2% of the total variance, but did not reach significance ($F(4,43)=1.23$, p=.314). Nevertheless, vocabulary was a significant predictor of verb diversity (β=.33, p=.046) and independently accounted for 8.8% of the total variance. The four biliteracy indices were again added to the baseline models for the various measures of narrative microstructure in Greek. The final regressions models for length and syntactic complexity are summarized in Table 56, and Table 57 presents the results for grammaticality and verb diversity. The analyses did not show any significant contributions of biliteracy to narrative abilities in Greek at the level of microstructure.

Table 54. *Baseline regression models for length and syntactic complexity of the Greek narratives.*

	Length			**Complexity**		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	-8.15	22.02		.95	11.97	
1. Age	.19	.14	.20	.23	.08	$.40^{**}$
1. Non-verbal IQ	.16	.14	.14	-.02	.08	-.04
1. Bilingualism at home	-.04	.07	-.08	-.03	.04	-.10
2. Vocabulary	.73	.21	$.48^{***}$	.34	.12	$.39^{**}$
ΔR^2 Model 2		.184			.120	
F_{Change}		11.76^{***}			8.80^{**}	
R^2 Model 2		.328			.415	
F		5.26^{**}			7.62^{***}	

Table 55. *Baseline regression models for the measures of grammaticality and verb diversity of the Greek narratives.*

	Grammaticality			Verb Diversity		
Step/Variable	*B*	*SE B*	β	*B*	*SE B*	β
1. Constant	75.84	23.81		53.91	13.37	
1. Age	-.21	.15	-.16	-.03	.08	-.06
1. Non-verbal IQ	-.04	.15	-.03	-.05	.09	-.09
1. Bilingualism at home	.21	.07	.31**	-.03	.04	-.10
2. Vocabulary	-1.35	.23	-.68***	.27	.13	.33*
ΔR^2 Model 2		.372			.088	
F_{Change}		34.75***			4.21*	
R^2 Model 2		.540			.102	
F		12.61***			1.23	

Table 56. *Contribution of the four biliteracy indices in the final regression models for length and syntactic complexity of the Greek narratives.*

	Length			Complexity		
Index	R^2	ΔR^2	*F*	R^2	ΔR^2	*F*
BIS1	.344	.016	1.00	.420	.005	0.38
BIS2	.356	.028	1.84	.439	.024	1.78
BIR1	.332	.003	0.21	.419	.004	0.31
BIR2	.345	.017	1.07	.444	.029	2.21

Table 57. *Contribution of the four biliteracy indices in the final regression models for grammaticality and verb diversity from the Greek narratives.*

	Grammaticality			Verb Diversity		
Index	R^2	ΔR^2	*F*	R^2	ΔR^2	*F*
BIS1	.546	.006	0.53	.115	.012	0.58
BIS2	.552	.013	1.18	.103	.001	0.02
BIR1	.556	.016	1.51	.130	.028	1.33
BIR2	.557	.017	1.63	.107	.005	0.23

5.7 Discussion

The aim of the present chapter was to investigate whether measures of biliteracy can explain variance in oral language skills in bilinguals, after controlling for age, non-verbal IQ, bilingual input in the home, and vocabulary. The research questions were based on the assumption that oral language abilities and reading skills form a reciprocal relationship. Although only few studies have directly investigated the effects of reading competency on oral language skills, the findings so far suggest that the influence goes indeed both ways (e.g., Connor et al., 2016; Verhoeven et al., 2011). Next, it was hypothesized that oral language measures differ in the extent to which they require language-specific knowledge and skills. For example, performance on the sentence repetition task is highly dependent on children's lexical skills and knowledge of syntax in the target language. Similarly, narrative abilities at the level of microstructure are, for the most part, language-specific so that limited language proficiency (especially productive skills) will affect aspects such as length, syntactic complexity, verb diversity and grammaticality of narratives produced in that same language (Iluz-Cohen & Walters, 2012). In contrast, it was argued that children's comprehension of oral narratives also depends on knowledge and skills that are language-invariant, such as knowledge of story structure and inferential skills, in addition to language-specific abilities. Consequently, significant contributions of biliteracy were anticipated for the measure of listening comprehension, especially for questions about mental states of characters as these typically required the children to make inferences. On the other hand, no significant effects of biliteracy were predicted for grammaticality and structure scores in the SRT, and for narrative measures at the level of microstructure after controlling for age, non-verbal IQ, balanced input at home and vocabulary skills. For overall accuracy on the SRT, it was conjectured that biliteracy might show a significant contribution due to the fact that correct sentence recall depends on working memory skills which might be positively affected by biliteracy. The following sections discuss the results for sentence repetition, narrative comprehension and narrative microstructure skills in turn.

Sentence repetition

The results for the English SRT scores showed no significant contribution of biliteracy after controlling for age, non-verbal IQ, English vocabulary and balanced input at home. As expected, a considerable amount of the total variation was explained by children's vocabulary scores (18–28%). Although the correlational analyses showed additional associations between non-verbal IQ and SRT scores, non-verbal IQ did not come out as a significant predictor once vocabulary was included in the models. This suggests that the relationship between English SRT scores and non-verbal IQ was mediated by vocabulary scores. For Greek, the amount of individual variation in SRT scores explained by vocabulary was nearly twice as much compared to English (40–54%). The larger contribution of vocabulary to SRT scores in Greek compared to English might be due to the fact that Greek was overall the children's weaker language and/or due to the larger individual variation in Greek. Importantly, the final regression models showed significant positive contributions of biliteracy to Greek SRT. More specifically, both performance-based indices accounted for a small, but significant amount of variance in SRT accuracy scores in Greek, which is in line with the moderate associations observed in the correlation analyses. The amount of explained variance in the final models was slightly larger for BIR2 (5%) than for BIR1 (4.5%), suggesting that overall level of decoding skills across the two languages was a slightly better predictor than balanced performance across English and Greek. The fact that both BIR1 and BIR2 came out as significant predictors is consistent with the highly significant correlation between the two scores obtained in the correlational analysis. The strong association between the BIR1 and BIR2 reflects the fact that the bilingual children performed at a high level in both English and Greek, with only small differences across languages. Hence, for the performance-based indices, it is difficult to compare the effects of balanced reading skills and actual level of reading skills across the two languages, since balance and actual level of proficiency were highly conflated for the measure of word reading ability. Note that the performance-based indices contributed to SRT accuracy, but not to grammaticality and structure scores, despite the significant associations obtained in the correlational analyses. This indicates that SRT accuracy scores tap a somewhat different (possibly wider) skill set than grammaticality and structure scores. Moreover, the results for the performance-based scores are consistent with the hypothesis that biliteracy contributes to oral language abilities via executive function skills, since both decoding skills and accuracy on sentence repetition tasks have been associated with working memory (Marinis & Armon-Lotem, 2015; Nevo & Breznitz, 2013; Riches, 2012). However, if working memory or other aspects of EF were indeed driving the biliteracy effect, it is unclear why biliteracy did not contribute to SRT scores in English. One possible explanation is that there was not enough variation in English SRT scores to detect any contribution of biliteracy. The mean scores for English ranged between 89-96% with standard deviations between 6-8%, while in Greek mean scores were between 62-82% with large *SD*s of 17-27%. Alternatively, it is possible that sentence repetition in the children's weaker language is more taxing on working memory than sentence repetition in the stronger language. Future studies with bilingual children who show more variation in terms of language skills in the majority language might prove fruitful.

Regarding the experience-based indices, BIS2 emerged as a significant predictor for all three SRT measures in Greek, explaining 4–7% of the total variance. Note that the correlational analyses did not indicate any significant associations between BIS2 and Greek SRT scores, suggesting that the relationship was obscured by one of the control variables, most likely age[47]. Recall that the expectation was for children with higher levels of biliteracy (i.e., higher BIS2 scores) to show better performance than children with lower levels of biliteracy. However, the regression coefficients for BIS2 were negative indicating that the effect went in the opposite direction. It is unclear why children with overall less instruction across the two languages would score higher on sentence repetition in Greek. The most likely explanation is that BIS2 scores are confounded by some factor related to exposure to English and Greek. Thus, the schooling-based indices calculated in this study might not be an accurate measure of children's levels of biliteracy. This highlights the need to perform elaborative statistical procedures in order to validate the proposed measures of bilingualism and biliteracy.

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[47] In line with this, the partial correlations between BIS2 and SRT scores with age kept constant yielded significant negative associations (*r*s between -.421 and -.494, all *p*s<.004).

Narrative comprehension

Turning to possible effects of biliteracy on narrative comprehension, the results showed that none of the four indices was able to account for a significant amount of additional variance in listening comprehension sores in either language after controlling for age, non-verbal IQ, bilingualism at home and vocabulary. For English, the correlational analyses showed no significant associations between the three comprehension scores and the predictor variables. Accordingly, none of the control variables made a significant contribution in the baseline regression models, and the total amount of variance explained by the models was very low (between 3-6%). For Greek, on the other hand, vocabulary came out as a significant predictor in the baseline models for total comprehension scores, accounting for 12% of the total variance. Separate analyses for the two types of questions showed that vocabulary explained 19% of individual variance in scores for mental state questions, while its contribution to factual questions was not significant. The results from the regressions were only partly in line with the correlation analyses. For mental questions, the contributions of age and vocabulary were consistent with the marginally significant associations from the correlational analyses while for total comprehension scores, the contribution of vocabulary in the baseline model was not predicted on the basis of the correlational evidence. Moreover, the significant association between BIS2 and mental questions was not borne out in the final regression model as the contribution of BIS2 was only marginally significant. However, note that both age and BIS2 made *negative* contributions to scores on mental state questions suggesting that younger children and children with overall less formal instruction did better on these question types than older children and children with more schooling. It is possible that the negative contribution of age is due to task effects in that the contents of the story were more appropriate for younger children who were consequently more attentive to the model story and also more invested in the task overall. Similar arguments could be made for BIS2 in that children with more schooling experience were for some reason less invested in the task. The effect was not present in English which might be due to English being the children's dominant language given its status as majority language. Another caveat is that the content of the stories and the comprehension questions themselves might have been too easy for the children of the age range tested. The average score was 92% for English and 87% for Greek and both measures showed little variation across the bilingual sample (English: *SD*=6 and Greek: *SD*=10) pointing to possible ceiling effects.

Narrative microstructure

The results for the narrative microstructure measures did not yield any significant contributions of biliteracy either. This is consistent with previous studies showing no relationship between literacy and narrative abilities at the microstructure level (e.g., Andreou, 2015; Bitetti & Hammer Scheffner, 2016). For English, the pattern of predictors in the baseline models was largely in line with the correlational analyses. Age was a significant predictor for length and syntactic complexity, while vocabulary made a significant independent contribution to grammaticality scores accounting for 22.6% of the total variance. However, the significant negative association between age and verb diversity obtained in the correlational analyses was not borne out in the regressions, as the contribution of age missed significance in the final model. Note that although the contribution of age was not significant in the model for the verb diversity measure, the negative coefficient as well as the negative correlation between age and verb diversity is puzzling. The strong negative correlation between narrative length and the verb diversity measure together with the positive association between age and story length indicated that the relationship between age and verb diversity was confounded by length. This was confirmed by follow-up analyses since the relationship between age and verb diversity disappeared when story length was controlled for. Thus, the verb diversity measure as calculated in the present study may be problematic for samples with relatively large differences in the overall length of the narratives as previously pointed out (e.g., Treffers-Daller & Korybski, 2016). The correlational analyses further indicated significant associations between some of the biliteracy indices and the measures of story length and syntactic complexity. However, none of these associations turned out significant in the final regression models.

For Greek, the results showed that both age and vocabulary correlated with all of the narrative microstructure measures yielding moderate to strong effect sizes, with the exception of age and verb diversity which did not correlate. The correlations with vocabulary were all borne out in the regression models where lexical skills accounted for a sizable amount of unique variance (9–37%). In contrast, age turned out as a significant predictor only for the syntactic complexity measures, while for the measures of story length and grammaticality, the contribution of age did not reach significance when vocabulary was included in the model. For the grammaticality measure, bilingualism at home also emerged as a significant predictor in the baseline model. Children with relatively balanced input at home produced fewer grammatical errors in their narratives than children with unbalanced input. Recall that bilingualism at home was calculated as the difference in the relative amount of exposure to English and Greek in the home environment, so that low scores reflect balanced exposure to the two languages. Thus, balanced input at home ensures that the children receive a substantial amount of input in Greek which explains the contribution of bilingualism at home to grammaticality of the narratives in Greek. Greek is the minority language which means that exposure to Greek is largely confined to the home, at least for the children attending English primary schools (n=37). For English, on the other hand, exposure at home is less relevant because of its status as the majority language which would explain why bilingualism at home did not predict grammaticality of narratives in English. Like with the English measures, the correlations pointed to a number of significant associations between the Greek outcome variables and the various biliteracy indices, especially the two based on word reading skills (i.e., BIR1 and BIR2). Despite these associations, none of the four biliteracy indices was able to account for a significant amount of variance in narrative microstructure measures after controlling for age, non-verbal IQ, bilingualism at home and vocabulary.

The relatively large contribution of age to story length and syntactic complexity in English suggests that for the majority language, bilingual children's performance on measures of narrative microstructure is highly contingent on cognitive maturity. In contrast, for the minority language Greek, language proficiency (as indexed by vocabulary scores) is by far the best predictor of narrative abilities at the level of microstructure. The present results for Greek are in line with findings from Andreou (2015) where language proficiency together with a measure of early literacy preparedness predicted bilingual children's performance on narrative microstructure in Greek. However, the analysis in Andreou (2015) included both children for whom Greek was the minority language and children for whom Greek was the majority language. Thus, future studies are needed to confirm that the contribution of vocabulary to narrative microstructure skills varies indeed as a function of language status.

Summary

The present study provides some first indication of a positive impact of biliteracy on oral language skills in the bilingual children's minority language. Biliteracy, as measured by children's performances on a word reading task in the two languages, accounted for a small amount of additional variance in SRT accuracy in Greek. In contrast, no effects of biliteracy were observed for story comprehension and narrative abilities at the level of microstructure. Thus, the results are consistent with the hypothesis that biliteracy positively impacts oral language skills via executive function skills. Given that the majority of the children attended English mainstream primary schools, the findings imply that literacy instruction in the minority language has a positive effect on children's processing abilities of oral language input. One of the limitations of the study was that some of the measures, especially for English, might have produced ceiling effects. Thus, for the comprehension questions, it is possible that a more difficult task with more age-appropriate stimuli would result in more variation in children's scores, and thus, potentially yield different findings. In any case, the fact that there was no correlation between questions about factual information and questions probing mental states of characters in either language suggest that it is important to distinguish between different question types. Moreover, the present study did not look at possible effects of biliteracy on narrative skills at the level of macrostructure. In contrast to microstructure skills, macrostructure abilities are assumed to be largely language-invariant allowing children to transfer these skills across languages (Iluz-Cohen & Walters, 2012). Hence, macrostructure skills are less dependent on language proficiency than microstructure skills and might therefore be more prone to be affected by levels of biliteracy. Although the present results point to the potential of measures of biliteracy to predict oral language skills, the findings need to be confirmed in future studies.

More specifically, performance-based indices should be based on more comprehensive measures of reading skills, such as reading comprehension. This would ensure that there is enough individual variation in performance to tease apart the two aspects of biliteracy, namely balance and level of proficiency across the two languages. Another caveat is that biliteracy as indexed by amount of schooling in the two languages is a fairly crude measure of literacy input. Moreover, the interpretation of the significant negative effect of BIS2 remains somewhat difficult due to possible confounds with other aspects of bilingual language input. Thus, it might be useful to develop more comprehensive measures of amount of formal instruction that take into account differences across countries and schools, as well as literacy practices in the home context.

In the present study, the prominent role of vocabulary for oral language skills in the minority language was evident in the results for the sentence repetition task, narrative microstructure skills, as well as story comprehension (especially for questions about mental states of characters). Vocabulary also made strong contributions to SRT scores in the majority language English, while it did not predict story comprehension or microstructure skills other than grammaticality of the produced narratives. The fact that in both languages, vocabulary made larger contributions to SRT performance than to narrative microstructure skills might be explained by differences in task demands. In the SRT, children need to repeat a set of pre-determined vocabulary items, while in the narratives, children have more choice of which words they want to use, although they do hear a model story to help them activate the relevant lexical items in their mental lexicons. As such, narrative production is less dependent on lexical skills than is performance on sentence repetition tasks, which should be taken into consideration when using these measures for language assessments.

CHAPTER 6 – BILITERACY & EXECUTIVE FUNCTION SKILLS

6.1 Research hypotheses & predictions

The aim of this chapter is to investigate the relationship between biliteracy on the one hand, and performance on executive function tasks on the other. Early research on the interactions between bilingualism and executive function abilities have consistently found better performance of bilinguals on certain EF tasks compared to their monolingual peers (see Adesope et al., 2010, for review). However, more recent studies have produced increasingly mixed results, with many failing to find a bilingual advantage in executive function skills (e.g., Gathercole et al., 2014; Morton & Harper, 2007; Paap & Greenberg, 2013) . One of the reasons for the inconsistent findings has to do with the fact that bilingualism is often treated as a categorical variable rather than a continuous one. Thus, it is likely that the conflicting results in the literature are at least partly due to poorly controlled designs that did not sufficiently take into account individual differences within the bilingual samples. Bilingual speakers differ immensely from each other in terms of level of proficiency and frequency of use of the two languages and these factors have to be taken into consideration in studies on bilingualism (Luk & Bialystok, 2013). This has been recognized early on by Cummins (1976, 1979) who proposed that bilinguals need to reach a certain threshold level of linguistic competence in both languages before bilingualism can have positive effects on cognitive development (threshold hypothesis). Taking vocabulary as the prime example, the rationale is that bilinguals with a large vocabulary in both languages also have a larger overlap of the two vocabularies (i.e., many concepts for which labels are available in both languages). A large shared vocabulary across the two languages results in high levels of co-activation in the brain. The high level of co-activation in bilinguals leads to increased lexical competition which, in turn, requires cognitive control (see Crivello et al., 2016, for similar arguments). Consequently, cognitive control has been argued to lie at the root of the bilingual advantage observed in tasks that require inhibition of conflicting information and switching between mental sets (Bialystok, Craik & Luk, 2012) . However, Gathercole et al. (2014) pointed out that the way in which language input is distributed across different contexts may affect the amount of shared vocabulary and therefore, levels of co-activation in bilinguals. Children who speak both languages in a given context (e.g., home or school) are likely to have more overlapping vocabulary than children who use their languages in different contexts. Moreover, it is hypothesized that developing literacy in addition to oral proficiency results in stronger representations of language material in the brain. More specifically, it is argued that learning how to read leads to an additional level of representation of lexical entries, namely the orthographic level. Lexical entries that include orthographic information in addition to semantic and phonological information are assumed to be ‘qualitatively better’ than those that contain only semantic and phonological information

(Lexical Quality Hypothesis, see Perfetti & Hart, 2002). Moreover, the quality of the representation determines how much activation a lexical entry receives and how fast it is accessed. High quality representations receive a lot of activation which means that they are also more likely to cause interference or competition during bilingual processing. Thus, it is argued that bilinguals who are also biliterate employ more cognitive control because they experience higher levels of co-activation of the two languages in the brain than bilinguals who are literate in one language only. In line with this suggestion, Bialystok and Barac (2012) found that bilingual children's executive control performance was positively influenced by increased experience in a bilingual education environment (i.e., time spent in an immersion program). These findings suggest that biliteracy might be one of the key factors driving the bilingual advantage in executive function skills. The present study seeks to test this hypothesis by examining the possible contributions of experience-based and performance-based indices of biliteracy to measures of different executive function skills. To the extent that the biliteracy indices reflect amount of shared or overlapping linguistic knowledge between the two languages, it is predicted that lower scores on the BIS1/BIR1 and higher scores on the BIS2/BIR2 will be associated with overall, better performance on the EF measures. More specifically, the research questions addressed in this chapter are:

i. *Do measures of biliteracy explain additional variance in non-verbal EF measures after controlling for age, non-verbal IQ and bilingual input at home?*

Evidence for a bilingual advantage has been reported for all of the three non-verbal EF measures used in the current study. Inhibition is the component that has produced the most evidence for a bilingual advantage (e.g., Bialystok, 1999; Carlson & Meltzoff, 2008; Poarch & van Hell, 2012) which makes it the prime candidate for effects of biliteracy. Moreover, Bialystok and Barac (2012) found that time spent in an immersion program made a significant contribution to children's performance on a flanker task which is one of the most frequently used measures of inhibition. Given these findings, it is predicted that inhibitory control abilities (as measured by the size of the congruency effect) will vary as a function of degree of biliteracy. With regard to switching abilities, some studies have found a bilingual advantage (e.g., Prior & MacWhinney, 2010; Wiseheart et al., 2016), but others have failed to find any significant differences between bilinguals and monolinguals (e.g., Paap & Greenberg, 2013). Also, studies have used different measures of switching abilities which might be partly responsible for the discrepant findings (Hernández et al., 2013). Bialystok and Barac (2012) is the only study that has looked at the relationship between bilingual education and switching abilities. The authors found only limited evidence for an effect of bilingual schooling on switching abilities in that there was an effect on the global switching cost (i.e., mixing cost) in one of two experiments, but only for the Grade 5 children. In contrast, the analysis showed no effect of time spent in the immersion program for the global switching cost in Grade 2 children, and no relation between bilingual education and the local switching cost. In the present study, biliteracy is expected to make a significant contribution to the size of the (global) switching cost, although the contribution is likely to be smaller than that for the measure of inhibition. Finally, several studies have found a bilingual advantage on tasks tapping non-verbal working memory. For example, Blom et al. (2014) found better performance on a non-verbal WM task (dot-matrix task) by bilinguals compared to monolinguals after controlling for vocabulary and SES (see also Kerrigan, Thomas & Bright, 2016; Morales et al., 2013). Importantly, Andreou (2015) found that biliterate bilinguals (i.e., children who received formal instruction in both languages) outperformed monoliterate bilinguals on non-verbal working memory skills. Given these findings, it is hypothesized that biliteracy will make a significant contribution to children's performance on the Mr. X task.

ii. *Do measures of biliteracy explain additional variance in verbal EF measures after controlling for age, non-verbal IQ, bilingual input at home and vocabulary?*

Research that have used executive function tasks with a verbal component tend to find a bilingual advantage when differences in language proficiency are controlled for (e.g., Bialystok et al., 2008; Blom et al., 2014; Luo et al., 2010). Blom et al. (2014) used the same digit backwards task employed in the current study and found better performance on part of the bilinguals compared to their monolingual peers after controlling for differences in SES and vocabulary. Bialystok et al. (2008) compared verbal fluency of monolingual and bilingual children with the bilingual children being divided into those with high and low English proficiency. Results for the letter fluency task showed that the high proficiency bilinguals outperformed their monolingual peers and the bilinguals with low English proficiency. Only one known study has used the n-back task to compare performance of monolingual and bilingual children, however results showed no group differences (Gangopadhyay, Davidson, Weismer & Kaushanskaya, 2016). Moreover, a few studies have used versions of the n-back task with bilingual adults and did not find any evidence that bilingualism affects task performance (e.g., Soveri, Rodriguez-Fornells & Laine, 2011; Yow & Li, 2015). With regard to the possible contribution of biliteracy, Marinis et al. (under review) found that bilingual education was a significant predictor of children's performance on a 2-back task. Similarly, Andreou (2015) found superior performance by biliterate bilinguals on a measure of verbal WM (digit backwards task) and updating (2-back task) compared to monoliterate bilinguals. Thus, it is expected that the biliteracy indices will explain additional variance in 2-back performance and in digit backwards scores in the current bilingual sample. In contrast, there are no studies investigating the relationship between biliteracy and performance on the letter fluency task.

Hence, no specific predictions are made as to whether biliteracy is associated with better performance on letter fluency.

iii. How do the results for the experience-based indices (BIS) and the performance-based indices (BIR) compare?

Despite the considerable number of studies that have investigated biliteracy in bilingual children, there is little consensus on how to best measure levels of biliteracy (Proctor & Silverman, 2011). In Marinis et al. (under review), biliteracy was measured on the basis of the number of hours of instruction received in each language, similar to the BIS indices in the current study. Bialystok and Barac (2012) compared the contributions of a performance-based measure of linguistic knowledge (i.e., vocabulary scores) and an experience-based measure of bilingualism/biliteracy (time spent in an immersion program) on metalinguistic awareness and executive function skills. The authors found that performance on the executive function tasks was predicted by bilingual experience (i.e., time spent in the immersion program), whereas metalinguistic awareness was predicted by performance on the vocabulary measure. Moreover, the findings by Blom et al. (2014) suggest that performance-based measures of bilingualism (i.e., vocabulary scores in the two languages) can be used to predict performance on executive function tasks. Although none of these studies have included both experience- and performance-based measures of biliteracy, the findings so far suggest that the two types of measures might show differential relationships with the various EF measures. Thus, it is anticipated that the effect of the various indices will vary across different tasks.

6.2 Data analyses

In a first step, simple bivariate correlations were carried out to locate significant associations between the various biliteracy indices and children's performance on the executive function tasks, and to detect potential issues with multicollinearity among the predictor variables. Next, fixed-order hierarchical multiple regressions were run for each executive function measure separately to determine the contribution of biliteracy to children's performances. A baseline model containing a number of control variables was run first to isolate effects from biliteracy from possible confounding variables. The baseline model was then compared against the full model to test whether the biliteracy indices made a significant contribution to children's performance on the EF measures over and above that of the control variables. The baseline model for the EF measures without a language component included age, non-verbal IQ[48] and bilingual input at home. A measure of bilingual input at home was included in order to disentangle bilingualism effects from biliteracy effects. The baseline models for the EF tasks

[48] i.e., standard scores from the Raven's

with a verbal component included expressive vocabulary as an additional predictor variable at step 2 in order to control for differences in language proficiency. The assumptions for multiple linear regression analyses were tested by identifying outliers with standardized residuals above the 3.29 threshold, and by locating data points for which Cook's Distance exceeded 1. The Durbin-Watson test was used to ascertain the independence of errors, and homoscedasticity was examined by inspecting the plots showing the relationship between the standardized predicted values and the standardized residuals. Multicollinearity was assessed on the basis of VIF values.

6.3 Results: Correlations

The correlation coefficients (Pearson's *r*) for the associations between the predictor variables and the various EF measures are given in Table 58. Non-verbal IQ was positively correlated with updating[49] , as well as with verbal WM in English and Greek (*r*s between .293 and .443, all *p*s<.04). The two measures derived from the Global-Local task, namely inhibition and switching showed a small correlation ($r(50)=.355$, $p<.011$). Moreover, switching showed a significant negative association with letter fluency in Greek ($r(50)=-.383$, $p=.006$), indicating better performance on letter fluency for children with smaller switching costs. The results further showed significant associations between all EF measures with a verbal component (i.e., updating, verbal WM in English and Greek, LF in English and Greek; *r*s between .369 and .778, all *p*s<.01), with the exception of updating and LF in Greek, which did not correlate. Turning to the predictor variables, age correlated positively with visuospatial WM, verbal WM in Greek, and LF in Greek, and showed a negative association with switching (*r*s between .347 and -.539, all *p*s<.02). Non-verbal IQ was positively correlated with all outcome measures (*r*s between .338 and .489, all *p*s<.02), except for the measures of inhibition and switching, and letter fluency in Greek. Bilingual input at home significantly correlated with updating ($r(48)=.307$, $p=.034$). English vocabulary showed significant associations with visuospatial WM, updating and letter fluency in English (*r*s between .411 and .489, all *p*s<.005), while Greek vocabulary correlated with verbal WM in Greek ($r(50)=.448$, $p=.001$), and letter fluency in Greek ($r(50)=.600$, $p<.001$). For the four biliteracy indices, BIS1 scores showed no significant associations with any of the outcome variables, but exhibited marginally significant correlations with visuospatial WM ($r(50)=.255$, $p=.081$), and verbal WM in Greek ($r(50)=-.256$, $p=.079$). The relationship between BIS1 and verbal WM went in the expected direction with children with more balanced schooling across the two languages performing better on the digit backwards task in Greek. However, the association between BIS1 and visuospatial WM was positive, indicating that children with unequal amounts of schooling in the two languages scored higher

[49] The results for updating are based on the composite scores from the 2-back task (rather than *A*' scores) since this scoring method has also been used in previous studies (e.g., Andreou, 2015; Marinis et al., under review).

on the Mr. X task than children with more balanced amounts of schooling across English and Greek. For BIS2 scores, there were significant correlations with visuospatial WM, switching, verbal WM in Greek, and LF in Greek (rs between .310 and -.323, all ps<.04), as well as marginally significant associations with verbal WM and LF in English (verbal WM: $r(50)=.277$, $p=.056$; LF: $r(50)=.240$, $p=.099$). Both performance-based indices correlated with all verbal EF measures (rs between -.373 and .603, all ps<.01), except for letter fluency in English. Moreover, BIR2 showed a significant correlation with visuospatial WM ($r(50)=.349$, $p=.013$), while the association between BIR1 and visuospatial WM was only marginally significant ($r(50)=-.263$, $p=.065$). Overall, BIR2 scores showed stronger correlations with the outcome measures than BIR1 scores. The results for the associations among the predictor variables were presented in the previous chapter in section 5.3 (Table 41). Recall that the correlations among the predictor variables showed little signs of multicollinearity, with the exception of the strong correlation between age and BIS2 scores ($r(48)=.697$, $p<.001$), suggesting that the results for BIS2 need to be validated with some additional statistical procedures.

Table 58. *Correlations between executive function measures and the predictor variables.*

	1.	2.	3.	4.	5.	6.	7.	8.
1. Visuospatial WM	--							
2. Inhibition	.040	--						
3. Switching	-.241†	.355*	--					
4. Updating	.443***	.141	-.194	--				
5. Verbal WM English	.388**	-.060	-.210	.470***	--			
6. Verbal WM Greek	.293*	-.103	-.241†	.369**	.778**	--		
7. LF English	.148	.055	-.254†	.393**	.453**	.405**	--	
8. LF Greek	-.017	-.128	-.383**	.191	.434**	.572**	.428**	--
Age	.347*	-.232	-.539***	.130	.245†	.374**	.064	.420**
Non-verbal IQ	.371**	.104	.054	.468***	.489***	.401**	.338*	.036
Bilingualism at home	.047	.103	-.023	.307*	.036	.014	-.076	.163
English vocabulary	.411**	.006	-.122	.489***	.188	.113	.418**	-.203
Greek vocabulary	-.158	-.197	-.224	.014	.225	.448***	-.018	.600***
BIS1	.255†	.174	-.079	.107	.069	-.256†	.211	-.081
BIS2	.310*	-.049	-.323*	.179	.277†	.304*	.240†	.314*
BIR1	-.263†	.036	.151	-.488***	-.433**	-.486**	-.154	-.373**
BIR2	.349*	-.048	-.233	.538***	.536**	.603**	.206	.439**

Note. WM = working memory; LF = letter fluency
† $p<.10$; * $p<.05$; ** $p<.01$; *** $p<.001$

6.4 Results: Regressions

6.4.1 Non-verbal executive function measures

The baseline regression models for the three executive function measures without a verbal component are given in Table 59. The model for visuospatial WM (i.e., Mr.X scores) fitted the data well ($F(3,44)=6.97$, $p=.001$), accounting for 32.2% of the total variance, with non-verbal IQ and age as significant predictors ($\beta=.39$, $p=.004$ and $\beta=.45$, $p=.001$, respectively) . However, for the measure of inhibition, the baseline model was only marginally significant ($F(3,44)=0.97$, $p=.077$), accounting for 14.3% of the total variance. Age was the only significant predictor in the baseline model for inhibition ($\beta=-.32$, $p=.031$), with older children showing smaller congruency effects (i.e., less interference on incongruent trials). The baseline model for switching provided a good fit for the data ($F(3,44)=6.46$, $p=.001$), accounting for 30.6% of the total variance. Age was again the only significant predictor in the model ($\beta=-.57$, $p<.001$). The negative relationship means that as children grow older, the size of the switching cost decreases. The contribution of biliteracy to visuospatial working memory (i.e., Mr. X scores), inhibition and switching was tested by adding the various biliteracy indices in an additional step to the baseline regression models. Table 60 shows the additional contribution of biliteracy to the three EF measures over and above the contributions of the predictors from the baseline models for each of the four indices separately. For visuospatial WM, the addition of BIS1 to the baseline model resulted in a significant change in R^2, with BIS1 accounting for 12.2% of additional variance ($F(1,43)=9.40$, $p=.004$). However, the beta coefficient for BIS1 was positive ($\beta=.39$, $p=.004$), suggesting that children who had received instruction predominantly in one language scored higher on the Mr.X task than children who had received similar amounts of instruction in English and Greek. For inhibition, none of the four indices was able to account for additional variance over and above the predictors from the baseline model. For switching, the addition of BIS1 scores led to a marginally significant improvement of the baseline model ($F(1,43)= 3.00$, $p=.091$), with BIS1 scores accounting for 4.5% of additional variance over and above the other predictor variables. The beta coefficient associated with BIS1 was negative ($\beta=-.23$, $p=.091$), indicating a tendency for children with unequal amounts of schooling in the two languages (i.e., higher BIS1 scores) to show smaller switching costs than children who had received similar amounts of schooling in the two languages.

Table 59. *Baseline models for the three non-verbal EF measures.*

	Visuospatial WM			Inhibition			Switching		
Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Constant	-20.12	8.03		270.15	201.55		3552.5	798.1	
Age	0.14	0.05	0.39**	-2.61	1.17	-.32*	-20.39	4.64	-.57***
NV IQ	0.18	0.05	0.45***	1.52	1.28	.17	-.26	5.07	-.01
BL at home	-0.01	0.02	-0.02	0.83	0.61	.20	2.24	2.43	.12
R^2		.322			.143			.306	
F		6.97***			2.44†			6.46***	

Table 60. *Contribution of the four biliteracy indices to the three non-verbal EF measures in the final regression models.*

	Visuospatial WM			Inhibition			Switching		
Index	R^2	ΔR^2	*F*	R^2	ΔR^2	*F*	R^2	ΔR^2	*F*
BIS1	.444	.122	9.40**	.148	.005	0.27	.351	.045	3.00†
BIS2	.329	.007	0.45	.171	.028	1.46	.309	.003	0.16
BIR1	.323	.001	0.02	.145	.002	0.09	.306	<.000	<0.01
BIR2	.323	.001	0.07	.144	.001	0.07	.306	<.000	0.01

6.4.2 Verbal executive functions measures

The baseline regression models for the verbal EF tasks included the same control variables as the models for the non-verbal EF tasks except that vocabulary scores were entered as an additional control variable at step 2. Different vocabulary scores were entered for the various measures, depending on the language in which the task was administered. Thus, the baseline model for updating (i.e., 2-back scores) included the vocabulary scores for the language in which the task was presented[50], while for digit backwards and letter fluency, the vocabulary scores for the respective language (English or Greek) were added to the baseline model. Tables 61 and 62 present the baseline models for the five verbal EF tasks. For updating, the baseline model provided a good fit for the data ($F(4,43)=7.40$, $p<.001$), and accounted for 40.8% of the total variance. Non-verbal IQ and bilingualism at home emerged as significant predictors (β=.59, $p<.001$ and β=.33, $p=.010$, respectively), while vocabulary scores did not make an independent contribution to updating over and above the other predictor variables in the baseline model. For verbal WM in English, the baseline model was significant ($F(4,43)=6.40$, $p<.001$), accounting for 34.6% of the total variance. Age and non-verbal IQ were both significant predictors (β=.35, $p=.010$ and β=.55, $p=.001$, respectively), with non-verbal IQ being the stronger predictor of the two. Vocabulary did not make an independent contribution to verbal WM in English. For verbal WM in Greek, the baseline model provided a good fit for the

[50] Recall that the bilingual children could choose in which language they wanted to hear the instructions for the 2-back task.

data (F(4,43)=9.06, p<.001), accounting for 45.7% of the total variance. From the three variables that came out as significant predictors, non-verbal IQ was the strongest (β=.43, p=.001), followed by age (β=.36, p=.016), and Greek vocabulary (β=.34, p=.005). Vocabulary contributed independently 9.3% of the total variance in verbal WM in Greek. For letter fluency in English, the baseline model was significant (F(4,43)=3.11, p=.025), accounting for 22.4% of the total variance. English vocabulary scores came out as the only significant predictor (β=.32, p=.050), with an individual contribution of 7% explained variance. The baseline model for letter fluency in Greek fitted the data well (F(4,43)=7.34, p<.001) and accounted for 40.6% of the total variance. Age and Greek vocabulary emerged as significant predictors (β=.27, p=.046 and β=.49, p=.001, respectively), with vocabulary being the stronger predictor of the two. Moreover, Greek vocabulary contributed 19.3% of the total variance over and above the other predictors from the baseline model.

Table 61. *Baseline models for updating and verbal WM in English and Greek.*

	Updating			**verbal WM English**			**verbal WM Greek**		
Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Constant	-7.04	20.71		-11.67	6.62		-11.85	5.47	
1. Age	.12	.12	.12	.10	.04	$.35^{**}$	.10	.03	$.36^{**}$
1. NV IQ	.65	.14	$.59^{***}$	.19	.05	$.55^{***}$	.13	.04	$.43^{***}$
1. BL at home	.17	.06	$.33^{**}$	-.01	.02	-.02	-.02	.02	-.13
2. Vocabulary	-.15	.22	-.09	-.06	.10	-.08	.14	.05	$.34^{**}$
ΔR2 Model 2		.006			.005			.093	
F_{Change} Model 2		0.42			0.30			7.34^{**}	
R^2		.408			.346			.457	
F		7.40^{***}			5.70^{***}			9.06^{***}	

Table 62. *Baseline models for the letter fluency task in English and Greek.*

	LF English			**LF Greek**		
Variable	*B*	*SE B*	β	*B*	*SE B*	β
Constant	-1.78	11.88		-7.46	9.27	
1. Age	.04	.07	.08	.12	.06	$.27^{*}$
1. Non-verbal IQ	.12	.09	.21	.03	.06	.06
1. BL at home	-.01	.04	-.04	-.01	.03	-.03
2. Vocabulary	.38	.19	$.32^{*}$	.33	.09	$.49^{***}$
Δ*R2* Model 2		.070			.193	
F_{Change} Model 2		4.03^{*}			13.93^{***}	
R^2		.224			.406	
F		3.11^{*}			7.34^{***}	

The contribution of biliteracy to the five measures of verbal executive function skills was tested by adding the four biliteracy indices to the baseline regression models. Tables 63 and 64 show the additional contributions of the biliteracy indices to performance on the five verbal EF measures. For updating, the results showed significant independent contributions of the two performance-based indices (BIR1: $F(1,42)=5.71$, $p=.021$; BIR2: $F(1,42)=6.46$, $p=.015$), with BIR1 and BIR2 scores accounting for 7.1% and 7.9% of the total variance, respectively. Neither of the experience-based indices led to a significant improvement to the baseline model for updating. The final models for verbal WM in English showed a significant contribution for BIR2 ($F(1,42)=6.51$, $p=.014$), as well as a marginal improvement to the baseline model with the inclusion of BIR1 ($F(1,42)=3.04$, $p=.089$). BIR2 accounted for an additional 10.2% of total variance and BIR1 explained an additional 4.4% of the total variance. For verbal WM in Greek, the results showed significant contributions of BIR1 and BIR2 over and above the predictors from the baseline model (BIR1: $F(1,42)=4.17$, $p=.047$; BIR2: $F(1,42)=11.60$, $p=.001$). The amount of additional variance explained was larger for BIR2 at 11.7%, while BIR1 contributed 4.9% to the total variance. In contrast, the experience-based indices did not explain additional variance in verbal WM in Greek. For letter fluency scores in English, the addition of BIS1 led to a significant improvement to the model ($F(1,42)=4.18$, $p=.047$), with BIS1 accounting for 7.0% of the total variance. However, the regression coefficient for BIS1 scores was positive ($\beta=.30$, $p=.047$) which means that children who had received schooling in predominantly one language scored higher on letter fluency in English than children with similar amounts of schooling in the two languages. None of the other biliteracy indices made a significant contribution to letter fluency scores in English over and above that of the control variables in the baseline model. For letter fluency scores in Greek, the inclusion of the four biliteracy indices did not lead to a significant improvement to the baseline model, although there was a marginally significant effect for BIR2 ($F(1,42)=3.04$, $p=.088$) which explained 4% of additional variance.

Table 63. *Contribution of the various biliteracy indices in the final regression models for the 2-back task and the digit backwards task in English and Greek.*

	Updating			**verbal WM English**			**verbal WM Greek**		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.408	.001	0.04	.366	.020	1.30	.465	.008	0.62
BIS2	.409	.002	0.12	.365	.019	1.22	.463	.006	0.47
BIR1	.479	.071	5.71^{*}	.390	.044	$3.03^{\dagger}$	.506	.049	4.17^{*}
BIR2	.487	.079	6.46^{*}	.448	.102	7.73^{***}	.575	.117	11.60^{***}

Table 64. *Contribution of the various biliteracy indices in the final regression models for letter fluency in English and Greek.*

	LF English			LF Greek		
Index	R^2	ΔR^2	F	R^2	ΔR^2	F
BIS1	.295	.070	4.18*	.414	.008	0.61
BIS2	.259	.035	1.98	.412	.007	0.49
BIR1	.226	.001	0.07	.435	.029	2.15
BIR2	.235	.011	0.58	.446	.040	3.04†

6.5 Discussion

This chapter aimed at examining the contribution of biliteracy to children's performance on a number of verbal and non-verbal executive function measures. Previous research investigating the relationship between bilingualism and executive function skills has produced mixed results (Adesope et al., 2010; Paap et al., 2015). The inconsistent findings across studies suggest that the cognitive advantages frequently observed in bilinguals are not due to bilingualism per se, but due to some particular aspect(s) of the dual language experience. One of the factors that might be responsible for the bilingual advantage in executive control is bilingual schooling. Support for this view comes from several studies that found positive effects of bilingual schooling on executive function skills (e.g., Andreou, 2015; Barac & Bialystok, 2012; Marinis et al., under review) The research questions were based on the premise that biliteracy is associated with higher levels of (balanced) bilingualism leading to increased executive control demands. Thus, it was anticipated that higher levels of biliteracy would be associated with overall better performance on the executive function measures. Moreover, it was reasoned that experience- and performance-based measures of biliteracy might show different patterns of relationships with the various EF skills. The following sections discuss the results for the three research questions addressed in this chapter.

Non-verbal EF measures

The results for the non-verbal measures of executive function skills did not point to any positive effects of biliteracy on children's performance. Age and non-verbal IQ emerged as significant predictors for visuospatial WM, while inhibition and switching yielded significant contributions of age only. For the measure of visuospatial WM, BIS1 scores made a significant negative contribution, accounting for 12.2% of the total variance over and above age, non-verbal IQ, and bilingualism at home. Note that the effect of BIS1 is consistent with the marginally significant correlation with Mr. X scores obtained in the correlation analyses. Thus, children who had received formal instruction in predominantly one language performed better on the Mr. X task than children who had received roughly equal amounts of formal schooling across the two languages. In contrast, the positive associations with BIS2 and BIR2 scores observed in the correlational analyses were not borne out in the regressions, since the two indices did not make a significant contribution to visuospatial WM skills. The present results are at odds with findings by Andreou (2015) where biliterate bilingual children outperformed monoliterate bilingual children on visuospatial WM. In the study by Andreou (2015), biliteracy was treated as a binary variable and the vast majority of the biliterate children (approx. 85%) attended bilingual immersion programs in different countries. In contrast, only about one third of the bilinguals in the current sample had received bilingual schooling in the context of an immersion program, with the remaining children having acquired Greek literacy mainly through Greek Saturday schools in the UK. Thus, the conflicting findings might be due to differences in sample characteristics. Alternatively, it is possible that the BIS1 scores were confounded by some other variable. For example, the distribution of BIS1 scores indicated that most of the children with higher scores on that index (>75) had received more instruction in English than in Greek. This points to the possibility that differences in the educational practices across countries might be responsible for the observed effects, which is in line with the suggestion that all speakers have alternative non-linguistic ways to improve executive function skills (Valian, 2015). Hence, the experience-based measures of biliteracy based on amount of schooling in the two languages might not be an accurate reflection of children's levels of biliteracy in the current sample.

The two measures of inhibition and switching did not provide any evidence for positive effects of biliteracy either. In fact, higher BIS1 scores were associated with smaller switching costs, although the effect was only marginally significant. Similar to the results for visuospatial WM, this suggests that children towards the monoliterate end of the spectrum tended to outperform children with higher levels of biliteracy as measured by relative amount of schooling received in the two languages. It is likely that the marginally significant effect of BIS1 scores is due to the index being confounded by some other variable, as argued above. Note that the correlational analyses did not indicate any associations between BIS1scores and the size of the switching cost. Instead, the correlations suggested that children with higher BIS2 scores exhibited smaller switching costs, but the relationship was not borne out in the regression models. The results for the switching measure are largely consistent with Bialystok and Barac (2012) who also failed to find a positive link between performance on a switching task and time spent in an immersion education program. However, the results for the inhibition measure are in contrast to Bialystok and Barac's (2012) finding that time spent in an immersion program reliably predicted performance on a Flanker task, which is one of the most commonly used measures of inhibition. A possible reason for the discrepant results of the current study might be the design of the Global-Local task from which the measures of inhibition and switching were derived. It has long been noted that one of the major challenges for the study of executive function skills is task impurity, which means that measures that are designed to tap into EF processes inadvertently implicate other non-EF processes (e.g., perceptual processing). Most of the studies that have used the Global-Local task with children have used simpler versions with only two types of stimulus shapes (e.g., Bialystok, 2010). In contrast, the version used in this study featured four different stimulus shapes which clearly increased the task demands. Moreover, the mapping of the four shapes to the respective response keys required some additional mental processes. Recall that the response keys were marked with the numbers 1 to 4 and children were instructed to press the number that shows how many lines are needed to draw the target shape. Thus, in addition to focusing on the correct level (global vs. local) and inhibiting the visual information from the non-target level, children had to remember the four mappings between the stimuli and the response keys. Hence, it is likely that the increased task demands in the current version of the task led to the large variation in reaction times which might have obscured the effects of biliteracy on children's performance. As such, it is possible that the Global-Local task used in this study is not suitable to detect biliteracy effects in children. Further research is needed to determine whether the effect of time spent in an education immersion program on inhibition skills found in Bialystok and Barac's (2012) study can be generalized to different populations of biliterate bilinguals or whether the effect is due to the specifics of the type of schooling.

Verbal EF measures

For the EF measures with a verbal component, the analyses yielded positive effects of biliteracy, after controlling for the contributions of age, non-verbal IQ, bilingual input at home, and vocabulary. More specifically, both performance-based indices accounted for a significant amount of variance in updating and verbal WM in English and Greek, although for English WM, the effect of BIR1 was only marginally significant. The amount of explained variance by the performance-based indices of biliteracy ranged between 7–12%. For all three measures, the effect was larger for BIR2 than for BIR1 suggesting that actual level of biliteracy across the two languages is a better predictor than a purely relative measure of balanced biliteracy. The moderate correlations between updating and verbal WM in English and Greek are consistent with the view that updating and working memory are highly related skills (Miyake et al., 2000). In contrast, the significant association between BIS2 scores and verbal WM in Greek was not borne out in the regressions, which is likely due to the strong correlation between BIS2 scores and age. The significant contribution of BIR scores to performance on the digit backwards and the 2-back task reflects the link that exists between verbal working memory skills on the one hand, and word reading abilities, on the other (Christopher et al., 2012). Although longitudinal data is needed to determine the direction of causality of the relationship, it is likely that the effects are reciprocal, in that biliteracy enhances verbal WM, while at the same time verbal WM supports literacy development. The fact that a measure of bilingual input at home was used as a control variable in the analyses suggests that the effects observed for BIR scores were not due to confounds with patterns of language exposure at home. Note that the results for BIR2 might reflect either benefits of biliteracy or positive effects of just overall higher levels of literacy. However, the fact that the purely relative measure of biliteracy (BIR1) also made significant contributions to verbal EF measures (albeit smaller than those of BIR2) indicates that it is not just overall higher levels of literacy that drive the effect. The results for updating corroborate Marinis et al.'s (under review) finding that balanced bilingual education is associated with superior performance on the 2-back task. In Marinis et al. (under review), biliteracy was measured as the proportion of formal instruction received in the two languages, similar to the BIS indices calculated in the present study. However, in the current study, effects of biliteracy were found for the indices based on performance on word reading tests in the two languages, but not for the experience-based indices based on schooling. On the one hand, the current findings suggest that biliteracy as indexed by performance on word reading tasks in the two languages are valid measures of biliteracy that are able to predict a significant amount of variance in 2-back scores, thereby extending Marinis et al.'s (under review) findings to performance-based measures of biliteracy. On the other hand, the fact that the schooling-based indices did not produce any significant biliteracy effects indicates that the BIS scores did not provide an accurate measure of levels of biliteracy in the current sample. It is possible that the skewed distributions for amount of schooling in the two languages introduced some confounds in the calculation of the indices. In contrast to the present study, Marinis et al. (under review) did not find significant effects of balanced bilingual schooling on digit backwards scores. This suggests that performance-based indices of biliteracy might be better predictors of EF skills than experience-based measures. Future studies are needed to confirm this hypothesis.

The results further showed a marginally significant contribution of BIR2 scores to letter fluency in Greek. Like the 2-back task, letter fluency requires both updating and monitoring skills. Children need to monitor their answers, update their working memory in order to avoid repetitions, and keep multiple rules in memory (e.g., no proper names, restrictions on morphologically related words, etc.). Thus, the 2-back and the letter fluency task tap into similar underlying skills, which is consistent with the significant associations obtained in the correlation analyses. In contrast, BIR2 showed no association with performance on letter fluency in English. Instead, the results for letter fluency in English revealed a significant effect of BIS1 scores, with an individual contribution of 10.7% of explained variance. However, the effect of biliteracy went in the opposite direction, in that children who had received formal schooling in predominantly one language scored higher than children who had received roughly equal amounts of formal instruction across the two languages. Thus, the results for letter fluency in English further point to the possibility that the BIS1 scores were confounded by some other variable related to exposure patterns in the two languages. Note that the correlation analyses did not show a significant association between BIS1 scores and letter fluency in Greek suggesting that the relationship was obscured by one of the other predictor variables. Moreover, the significant positive associations between BIS2 scores and letter fluency in English and Greek observed in the correlation analyses were not borne out in the final regression models, which is likely due to the strong correlation between age and BIS2 scores[51].

From the set of control variables included in the baseline models, non-verbal IQ emerged as the strongest predictor for updating and verbal WM in English and Greek. In contrast, vocabulary was the best predictor for performance on the letter fluency task in both languages, although the amount of individual variance accounted for by vocabulary was considerably larger in Greek than in English (7% vs. 19.3%). This reflects the fact that the 2-back and digit backwards task primarily tap into executive function skills which are highly contingent on general intelligence, whereas letter fluency is a hybrid task implicating both executive functions and verbal skills (i.e., vocabulary). Vocabulary also made a significant contribution to verbal WM in Greek, suggesting that limited oral language proficiency might be a confounding factor when assessing bilingual children's verbal WM skills in the minority language.

Experience- vs. performance-based measures

The findings from the present study are in line with previous research showing different patterns of associations with outcome measures for experience- and performance-based measures of bilingualism and biliteracy (e.g., Bedore et al., 2012; Bialystok & Barac, 2012). In the current study, the performance-based indices accounted for a significant amount of variance in updating and verbal WM, but not in letter fluency or non-verbal measures of EF. Recall that the performance-based measures used children's scores on word reading tests in English and Greek to index biliteracy. Thus, the effect of the performance-based indices is likely due to the fact that word reading implicates working memory, among other skills (Christopher et al., 2012). Decoding is a fairly one-dimensional measure of literacy skills, so it is possible that indices of biliteracy based on performance on a more global measure, such as reading comprehension, would yield different findings. This is because word reading skills are a prerequisite for reading comprehension and thus, acquired early on during literacy development. Moreover, decoding skills in a transparent language like Greek can be mastered with relative ease (Seymour et al., 2003), and decoding skills have been shown to be subject to crosslinguistic transfer in bilinguals (Melby-Lervåg & Lervåg, 2011). Thus, the performance-based indices used in the current study might not be an accurate reflection of the children's more global literacy skills. Nevertheless, the results show that verbal WM skills can be predicted by basic biliteracy skills (basic literacy skills in two languages). This parallels findings by Blom et al. (2014) who found that bilingual proficiency predicted performance on the digit backwards task. Note that bilingual proficiency

[51] Recall that there was some concern about multicollinearity in the analyses including BIS2 scores due to the high correlation with age. However, the values for the VIF statistic were below 3 in all the analyses suggesting that multicollinearity was not an issue.

was calculated on the basis of receptive vocabulary scores, which is also a fairly one-dimensional measure of oral skills.

As such, it could be argued that indices based on amount of formal schooling in the two languages provide more accurate measures of levels of biliteracy, since they capture a wide range of reading and writing practices. However, in the current study, the schooling-based indices yielded significant negative effects of biliteracy for some of the outcome measures (visuospatial WM and letter fluency in English). The results are difficult to interpret and do not fit well with findings by Marinis et al. (under review) and Barac and Bialystok (2012). Thus, it is likely that the experience-based indices used in the current study were confounded by some other variables. Recall that the BIS scores were calculated in terms of total amount of schooling, and did not take into account whether the children received formal instruction in the two languages concurrently or successively. This is relevant since recent studies with bimodal interpreters suggest that experience in managing bilingual demands might be the key factor that leads to a bilingual advantage in executive functions (Macnamara & Conway, 2014). Thus, bilinguals who use their two languages in different contexts (e.g., language A at home and language B in school) experience less interlanguage conflict than bilinguals who speak both languages in the same contexts. Although the bilingual children in the current study were all biliterate, only few children attended a bilingual day school[52], while for the majority the English day school and the Greek Saturday school constituted different instructional contexts. Hence, it can be argued that for the majority of the children, bilingual management demands in the school context were too low to have an effect on their executive function abilities. However, this raises the question why bilingual input at home did not contribute to any of the EF measures. Recall that bilingual input at home was gauged in terms of the difference in the frequency of use of the two languages at home. Thus, a low score on the bilingual input measure suggests that the two languages are used to roughly the same amount which means that bilingual management demands are high, while high scores indicate the use of predominantly one language such that bilingual management demands are low. Although the input measure used in the current analyses reflects bilingual management demands at home, it did not correlate with any of the EF tasks. It is possible that the measure of bilingual input calculated here was not sensitive enough to accurately reflect bilingual management demands, in that it did not take into account language input in the past. Previous patterns of language use in the home might be crucial as shown by Luk, De Sa and Bialystok (2011) who found evidence for age of onset effects in that early bilinguals showed less interference in a Flanker task, while the late bilinguals did not differ from their monolingual peers. The authors came to the conclusion that that cognitive control is positively affected by the bilingual experience in that longer time spans of active

[52] The Greek school in London used follow a fully bilingual program, however, at the time of recruitment the children were following the Greek curriculum with an additional five hours of English lessons per week.

bilingualism lead to greater advantages in executive functions. This further corroborates Bialystok and Barac's (2012) findings in that both studies show that the duration of the bilingual experience is a decisive factor with regard to the cognitive benefits of bilingualism. In the current study, the biliteracy indices that were derived from amount of schooling did not take into consideration whether children received formal instruction in the two languages concurrently or successively. Future studies are needed to determine whether factors such as age of onset of biliteracy and 'type' of biliteracy (i.e. simultaneous biliteracy vs. successive biliteracy) affect children's performance on EF measures.

Summary

The present results showed that performance-based measures of literacy are able to account for a significant amount of variance in updating and verbal WM skills, over and above the contributions of age, non-verbal IQ, bilingualism at home, and vocabulary. The findings are consistent with the view that biliteracy contributes to the cognitive advantage found in bilinguals, particularly skills that implicate (verbal) working memory. Bilingual input at home was included in the baseline model to ensure that any contributions of the biliteracy indices were not confounded by balanced proficiency or balanced oral language input. The measure of bilingual input at home did not correlate with any of the EF tasks, which is in line with Blom et al. (2014) who also failed to find a link between mothers' language use at home (one language vs. both languages) and children's performance on a range of working memory measures. The findings for the experience-based measures did not point to any positive contributions of biliteracy to either verbal or non-verbal measures of executive function skills. This is contrast to previous studies who found significant effects of amount of bilingual schooling on executive function skills. Thus, performance- and experience-based measures showed different patterns of relationships with executive function skills, although it is possible that the schooling-based indices were contaminated by some other exposure-related variable in the current sample.

CHAPTER 7 – GENERAL DISCUSSION

7.1 Summary of main findings

The present thesis investigated bilingual children's oral language and literacy skills in both of their languages, as well as their executive function abilities. The bilingual children's linguistic and cognitive profiles were examined through comparisons with monolingual control groups in each language. Moreover, the interrelationships between oral language, executive function and (bi)literacy were explored by conducting a series of regression analyses. Biliteracy was computed in two ways: based on amount of formal schooling in the two languages (BIS=biliteracy index schooling) and based on children's performance on a single word reading task in English and Greek (BIR=biliteracy index reading). Moreover, two different formulae were used, one reflecting balance (BIS1/BIR1) and one emphasising actual level of experience or proficiency (BIS2/BIR2). The monolingual and bilingual children that were tested were between 7 and 12 years old and came from middle and upper middle class families. The study targeted primary school children because of the major developments in reading skills that occur in this age range. The fact that all children came from middle to high socioeconomic backgrounds ensured that the results are not confounded by differences in SES which has been shown to play a crucial role in children's linguistic and cognitive development (Golberg et al., 2008; Hoff, 2006). The following sections summarize the main findings.

Language input: The bilingual sample was characterized by a high level of heterogeneity in terms of their current and previous patterns of language exposure. Consequently, the sample included children at both ends of the spectrum (extensive input in Greek-little input in English vs. little input in Greek-extensive input in English) which stresses the need to treat bilingualism as a continuous variable rather than a categorical one (Luk & Bialystok, 2013). As a group, the children had received more input in Greek than in English during early childhood, while current exposure at home showed roughly equal amounts of input in the two languages. Similarly, children's oral proficiency as rated by the parents did not differ between Greek and English, although it was reported that children used English more frequently than Greek throughout the day. Finally, amount of formal schooling, home literacy practices, and children's reading and writing skills (as rated by their parents) all indicated higher literacy levels in English compared to Greek.

Oral language skills: The group comparisons for measures of oral language skills showed significant differences in favour of the monolinguals on all measures in both languages, with the exception of story comprehension in English where the bilinguals were found to perform on a par with their English monolingual peers. In both languages, the group difference for vocabulary was twice as large as for the other measures. Moreover, the group effect for the various measures was nearly twice the size in the minority language Greek compared to

English. However, in all comparisons, the significant group effect disappeared when vocabulary scores were included as a covariate in the analyses. Thus, the bilinguals and monolinguals exhibited similar global oral language skills, but performance in the bilinguals was depressed due to their lower lexical skills.

Executive function skills: For non-verbal executive function skills, inhibition was the only measure that yielded a significant group effect, but contrary to the predictions, the Greek monolinguals outperformed the bilinguals, while the English monolinguals did not differ from either group. For EF measures with a verbal component, the analyses without vocabulary as a covariate showed a significant group effect only for letter fluency in Greek with the monolingual obtaining higher scores than the bilinguals. When differences in vocabulary were controlled for, the bilinguals were found to score significantly higher than the monolinguals on the measure of verbal WM in both English and Greek. There was also a tendency for the bilinguals to score higher than the monolinguals on the letter fluency task in English, while for the minority language Greek, the group difference in favour of the monolinguals remained even when vocabulary was included as a covariate.

Literacy skills: The bilinguals performed at the same level as their monolingual peers on all English literacy measures, with the exception of reading comprehension, where the bilinguals were found to score slightly lower than their monolingual peers. However, the difference in reading comprehension scores disappeared once vocabulary was controlled for. In addition, the analyses with vocabulary as a covariate indicated that there was a tendency for bilinguals to perform better than the monolinguals on rapid naming of digits and on the decoding measure in English. For the minority language Greek, the analyses without vocabulary as a covariate yielded significant group effects in favour of the monolinguals for all measures, except for the lexicality effect from the lexical decision task, which did not differ between the two groups. Moreover, the subgroup of bilinguals who were able to complete the passage comprehension subtest performed on a par with the Greek monolinguals, regardless of their lower vocabulary.

Profile effects: For the majority language English, the largest gap between monolinguals and bilinguals was observed for the measure of expressive vocabulary, followed by sentence repetition scores, and reading comprehension, which showed the smallest (significant) group difference for the English comparisons. For Greek, the measures with a strong lexical component (i.e., vocabulary, LDT accuracy, LF) were associated with the largest group effects. Slightly smaller group effects emerged for oral language and literacy skills (SRT scores, comprehension questions, decoding, and reading comprehension composite scores), while the bilinguals did not differ from their Greek monolingual peers on the more cognitive measures (i.e., verbal WM and lexicality effect). The comparison between the bilingual children’s performances in English and Greek showed a similar picture in that the largest differences across languages were observed for measures that pose high demands on vocabulary skills. For oral language skills, there were large differences between English and Greek SRT scores, while the effect of language status (minority vs. majority language) was much smaller (and sometimes non-existent) for story comprehension, and narrative skills at the level of microstructure. Moreover, the bilingual children exhibited only small differences between decoding skills in English and Greek, while performance on the verbal WM task did not differ across languages.

Decoding in English and Greek: Rapid naming made a significant independent contribution to word reading in both monolingual groups. Vocabulary did not account for any variance in the English monolinguals. In contrast, vocabulary emerged as a significant predictor for Greek monolinguals, although RAN was the better predictor out of the two. For the bilinguals, RAN shared most of its variance with the other variables and did not account for unique variance in decoding skills in either language. However, the results for the bilinguals showed significant independent contributions of verbal WM to word reading in both languages. Verbal WM was also associated with word reading in the two monolingual groups, but its effect was almost entirely shared with other variables. Moreover, the total contribution of verbal WM was twice as large in the bilinguals compared to the monolinguals in both English and Greek. Vocabulary also contributed to word reading in the bilinguals and emerged as a unique predictor in English, but not Greek. Overall, there was a large amount of shared variance among the predictor variables, especially for the bilinguals in the minority language Greek. Updating and letter fluency made additional independent contributions to word reading in the English monolinguals, while SRT scores emerged as significant predictors for the bilinguals in Greek. The set of predictors accounted for over 70% of the total variance in word decoding for the bilinguals in English, whereas the amount of total variance explained was considerably lower for the bilinguals in Greek and for the two monolingual control groups at 42–43%.

Reading comprehension in English and Greek: Oral language skills and decoding made significant independent contributions to reading comprehension in the bilinguals in both languages, with oral language skills being the better unique predictor of the two. In contrast, decoding skills showed no association with reading comprehension in the English monolinguals. For the Greek monolinguals, oral language skills did not explain additional variance over and above decoding skills. Moreover, the amount of variance explained by oral language skills was about twice as large in the bilinguals compared to the monolinguals. The results further showed significant additional contributions of RAN (English monolinguals), switching (Greek monolinguals and bilinguals in English), as well as updating and visuospatial WM (bilinguals in Greek). However, inhibition did not explain variance in reading comprehension in any of the groups. The amount of total variance accounted for by the set of predictors was 45% in the English monolinguals, while in the Greek monolinguals and the bilinguals in English and Greek, it was over 70%.

Biliteracy & oracy: Significant positive effects of biliteracy over and above the contributions of the control variables were observed for Greek sentence repetition scores. More specifically, both performance-based indices (i.e., BIR1 and BIR2) made significant contributions to SRT accuracy scores in Greek. The amount of independent variance accounted for by BIR1 and BIR2 was 4.6% and 5.1%, respectively. From the indices based on amount of schooling, BIS2 came out as a significant predictor for all three SRT scores, with independent contributions of 4–7%. However, the effect of BIS2 was negative in that children with high scores on this index (i.e., overall more schooling across the two languages) showed lower performance on the Greek SRT than children with lower BIS2 scores. No effect of biliteracy was observed for any of the other measures. For SRT scores in both languages, vocabulary was the best predictor, although the amount of explained variance was twice as large in Greek compared to English. Vocabulary was also the strongest predictor for comprehension questions about mental states of characters in Greek, while none of the control variables contributed to story comprehension in English. For measures of narrative microstructure in English, age emerged as the best predictor for story length and syntactic complexity, while vocabulary was the strongest predictor for grammaticality. For Greek, performance on all four measures was best predicted by vocabulary, and in the case of syntactic complexity, also age.

Biliteracy & executive functions: Positive effects of biliteracy were observed for verbal executive function measures, but not for non-verbal EF measures. Both performance-based indices of accounted for additional variance in updating and verbal WM in Greek, with independent contributions of 5–12%. For verbal WM in English, BIR2 made a significant independent contribution, while the effect for BIR1 was only marginally significant. The amount of variance explained by BIR2 scores was higher than the amount accounted for by BIR1 scores suggesting that actual levels of reading proficiency across the two languages is more important than balanced proficiency. From the experience-based indices, BIS1 scores were found to explain additional variance in visuospatial WM and letter fluency in English, with individual contributions of 12% and 7%, respectively. However, for both measures the effect of BIS1 was negative in that children who had received unequal amounts of instruction in the two languages performed better than children who had been exposed to similar amounts of formal instruction in both languages. For the non-verbal EF measures, performance was largely predicted by age, and in the case of visuospatial WM, also non-verbal IQ. Updating was best predicted by non-verbal IQ, and to a lesser degree bilingualism at home. The control variables that best predicted verbal WM skills were age and non-verbal IQ, and for verbal WM in Greek also vocabulary. For letter fluency, vocabulary emerged as the strongest predictor in both languages, with age being an additional predictor in Greek.

7.2 Synthesis

The first aim of the present thesis was to identify bilingual children's strengths and weaknesses across a range of language, literacy and cognitive measures. This was done by comparing the bilingual children's performances to a monolingual control group in each language. The second objective was to compare predictors of word reading and reading comprehension in monolingual and bilingual children in English and Greek. Thirdly, possible effects of biliteracy on oral language skills were investigated. Finally, the fourth aim was to examine the relationship between biliteracy and executive function skills. The following sections synthesise the results across the difference chapters and discuss the main findings of the present thesis.

Linguistic profiles in the minority and the majority language of bilinguals

The results from the group comparison were in line with previous studies showing large gaps between the monolinguals and bilinguals in the domain of vocabulary, while differences on measures of morphosyntactic and listening comprehension skills were considerably smaller (e.g., Babayiğit, 2014; Bowyer-Crane et al., 2017; Oller & Eilers, 2002). In fact, the bilinguals performed on a par with their monolingual peers on English story comprehension. The results from the regression analyses in chapter 5 are in line with the pattern from the group comparisons in that vocabulary made larger contributions to SRT scores than to story comprehension. Thus, sentence repetition taps into both morphosyntactic and lexical skills, even when alternative scoring methods are used (i.e., grammaticality and structure scores). Moreover, the fact that vocabulary did not make a significant contribution to story comprehension in English supports the claim that lexical skills are the primary source of group differences on more global measures of oral language skills. For English literacy measures, there was a small group effect for reading comprehension with the monolinguals outperforming the bilinguals, but no difference emerged for any of the other measures in English (see Babayiğit, 2015, for similar results). The bilinguals also did not differ from their monolingual peers on the measures of verbal WM and letter fluency in English. Thus, decoding and phonological processing skills are clearly areas of strength in bilinguals (August & Shanahan, 2006; Melby-Lervåg & Lervåg, 2014). This is further supported by the finding that when vocabulary was controlled for, the bilinguals scored higher than the English monolinguals on verbal WM, and there was a tendency for the bilinguals to perform better on RAN and decoding than the monolinguals. The results for verbal WM in Greek parallel the findings for English, supporting the claim that bilinguals show advantages in cognitive skills, more specifically verbal WM (see also Blom et al., 2014; Morales et al., 2013). Moreover, the high correlation between the bilinguals' digit backwards scores in English and Greek indicates that verbal WM skills are language-invariant and that the task is only weakly dependent on language proficiency. For the minority language Greek, the monolinguals outperformed the bilinguals on all measures, with the exception of the lexicality effect from the LDT, where the two groups did not differ. The lower performance on part of the bilinguals is to be expected given that as a group, they had received very little formal instruction in Greek. As with the oral language measures, all group differences in favour of the Greek monolinguals disappeared when vocabulary was included as a covariate in the analyses. The fact the bilinguals did not differ from their monolingual peers in terms of size of the lexicality effect indicates that bilingual children can develop age-appropriate orthographic processing and word reading skills in the minority language despite their limited language proficiency. The high correlation between the bilingual children's performances on the decoding measures in the two languages further supports the view that word reading skills are transferable across languages (Melby-Lervåg & Lervåg, 2011). Note that Greek is typically described as a language with high orthographic transparency which may be partly responsible for the apparent ease with which the bilinguals seem to have acquired word reading skills in Greek, even in the absence of sufficient oral language skills (see Bonifacci & Tobia, 2017, for similar arguments). The role of orthographic transparency for reading development in the minority language of bilinguals needs to be investigated in future studies. The finding that the bilingual children performed on a par with their monolingual peers on letter fluency in English despite the strong lexical component of the task suggests that the bilinguals are able to compensate for their lower vocabulary skills by relying on their enhanced executive function skills to perform at monolingual levels (see also Bialystok et al., 2008). Similar arguments could be made for decoding skills in English. However, in the minority language Greek, the gap in lexical skills was too big for the bilinguals to reach monolingual levels. For Greek, the measures with the largest lexical components (i.e., vocabulary, letter fluency, LDT accuracy) showed by far the biggest group effects, while for English the results seem to differ depending on whether the measure taps primarily expressive or receptive skills, as well as the extent to which the task implicates EF skills. The precedence of receptive skills over expressive skills is further evident in the results for story comprehension in both languages (i.e., no group effect in English and small group effect in Greek), which should be taken into consideration in bilingual assessments (see also Gibson et al., 2012). Finally, the results for the crosslinguistic comparisons and correlations of bilingual children's narrative microstructure abilities in English and Greek revealed considerable interdependence in terms of performance across languages. Story length and syntactic complexity did not differ across languages, and showed moderate crosslinguistic correlations. In contrast, the two measures that depend more on lexical skills, namely lexical diversity and grammaticality, showed crosslinguistic differences in favour of the majority language English. Although there was no monolingual data available for comparison, the fact that story length and syntactic complexity were invariant across languages is surprising in light of the children's relatively limited language proficiency in Greek, as evidenced by their expressive vocabulary scores. It is possible that the bilingual children's unexpectedly high scores on the Greek microstructure measures are the result of frequent home literacy activities (see Leseman et al., 2007). This would also explain the relatively high performance on story comprehension in both languages. Moreover, the significant crosslinguistic correlations suggest that crosslinguistic transfer is not limited to macrostructure skills, but can also occur in the domain of microstructure (cf. Bedore et al., 2010; Uccelli & Páez, 2007). Taken together, the results show similar linguistic profiles in the minority and majority language of bilinguals, with a strong tendency for group differences to be more marked in the minority language (see also Gathercole & Thomas, 2009). Note that although English was the majority language for all the bilingual children since they were residing in the UK, not all of the children had English as their dominant language. Recall that the bilingual sample was fairly heterogeneous in terms of length of exposure and amount of input in the two languages (children from mixed marriages, recent immigrants, 2nd generation immigrants). Hence, conclusions regarding differences in profile effects between the minority and the majority language can only be tentative. Future investigations that take into consideration the children's language dominance can shed further light on how bilingual profile effects interact with language status.

Word reading and reading comprehension in monolinguals and bilinguals

For the majority language English, the results from the group comparisons showed that the bilinguals had nearly 'caught up' with the monolinguals on reading comprehension[53], while their basic literacy skills were already comparable to that of monolinguals. In Greek, the bilinguals seemed to lag behind their monolingual peers in both basic reading skills and reading comprehension, although the analyses for the passage comprehension subtest indicated that those bilinguals who had sufficient reading skills to complete the test, performed at the same level as their monolingual peers. This shows that it is in principle possible for bilinguals to perform at the same level as monolinguals on measures of reading comprehension. The finding that decoding skills seem to be transferable across languages, and the fact that the bilingual children performed close to monolingual levels on English reading comprehension, despite their lower vocabulary skills, point to differences in the relative contributions of underlying component skills between monolinguals and bilinguals (Droop & Verhoeven, 2003). This possibility was investigated by examining the predictors of word reading and reading comprehension in monolinguals and bilinguals in English and Greek.

On the whole, the findings from chapter 4 support the view that L1 and L2 reading development across languages that differ in orthographic consistency show both similarities and differences (Geva & Siegel, 2000). Both word decoding and reading comprehension were predicted by and large by the same set of underlying skills in both groups and languages (see also Droop & Verhoeven, 2003 and Verhoeven, 2000). For word decoding, the main difference

[53] In fact, the standard scores from the YARC showed that as a group, the bilinguals performed well within the norms (*M*: 108, *SD*:11, range: 73-135), with only two children scoring below the 85 threshold. This finding is quite remarkable given that some of the children had been living in the UK for a few years only.

between groups was that RAN was a better predictor for the monolinguals, while verbal WM made larger contributions in the bilinguals. This is in line with previous studies that found different predictors of word reading in monolinguals and bilinguals (e.g., Bellocchi et al., 2017; Kremin, Arredondo, Hsu, Satterfield & Kovelman, 2016). The commonality analyses further showed that in both languages, the total contribution of verbal WM was twice as large in the bilinguals compared to the monolinguals. Moreover, SRT accuracy scores, which are assumed to depend partly on verbal WM skills, emerged as a significant additional predictor for the bilinguals in Greek. This underscores the importance of verbal WM for word decoding in bilinguals (Geva & Siegel, 2000). It is possible that the larger contribution of verbal WM in the bilinguals compared to the monolinguals reflects a bilingual compensation strategy to overcome limitations in vocabulary knowledge. This idea aligns well with the finding that bilinguals show better working memory skills compared to monolinguals (see chapter 2). Alternatively, it could be argued that the word recognition process is less automatized in bilinguals due to their lower lexical skills, so that they are ‘forced’ to rely more on phonological recoding than on sight-word reading compared to monolinguals, although this does not necessarily affect reading accuracy since bilinguals performed at the same level as monolinguals in the majority language English. However, the fact that verbal WM was found to play a greater role in bilinguals compared to monolinguals in both English and Greek suggests that this is not just a transient effect, since their reading skills in English were much more advanced than in Greek. Thus, the present results are more consistent with the idea that bilingualism leads to cognitive advantages in working memory which in turn can be used as a compensatory strategy to achieve word reading skills comparable to monolinguals. For the monolinguals, the lack of a significant effect of verbal WM over and above the other predictor variables is at odds with previous studies (e.g., Gottardo et al., 1996). One reason for the discrepant findings might be the inclusion of different sets of control variables in the regression models across studies. Alternatively, the conflicting findings might be due differences in the tasks used to measure verbal WM skills. For example, Gottardo et al. (1996) measured verbal working memory skills by means of a listening span task, which poses much higher demands on language than the digit backwards task used in the current study. Thus, the contribution of working memory to word reading skills is likely to differ as a function of the language demands of the task tapping working memory.

For RAN, the analyses of unique and shared variances revealed substantial total contributions in both groups and languages, although for English the overall effect was larger in the bilinguals, while in Greek the opposite was the case. However, in the bilinguals, the contribution of RAN was almost entirely shared with the other predictors in the model which explains why RAN did not make an independent contribution to word reading in this group. For Greek, RAN was associated with larger unique and total contributions in the monolinguals compared to the bilinguals. This might indicate that the word reading process is more automatized in the monolinguals, since RAN is more strongly related to reading fluency (Araujo et al., 2015). For English, RAN was a better unique predictor in the English monolinguals, but its total contribution was larger in the bilinguals. The findings for English are difficult to interpret and future research is needed to clarify the RAN-reading relationship in bilinguals at different stages of reading development. The results regarding the contribution of vocabulary to word reading skills in English and Greek show a complex picture. For the English monolinguals, there was no relationship between vocabulary and word reading, which is in contrast to previous findings (e.g., Suggate et al., 2014). It is possible that the lack of a significant contribution of vocabulary in this group is due to ceiling effects. In support of this, letter fluency, which is heavily dependent on lexical skills, emerged as an additional significant predictor of word reading in the English monolinguals. For the bilinguals and the Greek monolinguals, the total contribution of vocabulary was found to be highly similar. However, while vocabulary emerged as a significant independent predictor in the Greek monolinguals and in the bilinguals in English, this was not the case for the bilinguals in Greek. Moreover, the commonality analyses showed that vocabulary and phonological processing skills (RAN and verbal WM) are highly interdependent in the minority language of bilinguals, which explains why vocabulary and RAN did not come out as unique predictors. In general, the analyses of covariances revealed large amounts of shared variances among the predictors in both monolinguals and bilinguals. This highlights the need to supplement regression analyses with communality analyses, given that the skills underlying reading may show different relationships among each other in bilingual and monolingual children.

For reading comprehension, the results for the bilinguals were highly consistent with previous research showing substantial contributions of oral language and decoding skills, with oral skills being the stronger predictor (e.g., Hoover & Gough, 1990). In contrast, a number of unexpected findings emerged for the two monolingual groups. For the English monolinguals, decoding had no effect on reading comprehension, whereas oral language skills made a small independent contribution over and above age and non-verbal IQ. On the one hand, the lack of a contribution of word reading in the English monolinguals is consistent with studies showing that the influence of decoding skills decreases throughout development (e.g., Catts et al., 2005; Gough et al., 1996).Thus, the fact that decoding still made a substantial contribution to reading comprehension in the bilinguals might suggest that they are at an ‘earlier’ stage in the acquisition process. However, this does not align well with the finding that the group difference for English reading comprehension was very small, and the fact that the bilinguals performed well within the norms on English reading comprehension. On the other hand, the independent contribution of decoding in the bilinguals was merely 5% and decoding shared most of its variance with other predictors. The higher level of interdependence between reading component skills in bilinguals might explain the stronger link between decoding and reading comprehension in the bilinguals compared to the monolinguals. Nevertheless, the results for English confirm the limited role of decoding skill as a unique predictor of reading comprehension at advanced stages of reading development in both monolinguals and bilinguals (Gough et al., 1996). This conclusion is supported by the Greek data, where the independent contribution of decoding was very small in both groups (4–5%). However, the commonality analyses revealed again high levels of interdependence among the predictor variables in both groups. Consequently, the unique contributions of decoding and oral language skills to reading comprehension in the Greek monolinguals were very small. In contrast, oral language skills contributed a substantial amount of unique variance in the bilinguals, despite the large amounts of variance shared among the predictor variables. Thus, the results are in line with previous studies reporting stronger links between oral language skills and reading comprehension in bilinguals compared to monolinguals (e.g., Babayigit, 2014; Droop & Verhoeven, 2003).

The finding that decoding made a small contribution in the Greek monolinguals but not the English monolinguals is inconsistent with the claim that the word reading skills show stronger links with reading comprehension in beginner readers of opaque orthographies (Florit & Cain, 2011). However, the reading comprehension measures in English and Greek used very different task formats, which makes it difficult to compare the results across the two languages. For example, it is conceivable that answering of multiple choice questions relies more on word reading skills because the options tend to be only minimally different, rendering accurate decoding paramount. Differences in task format might also be responsible for the different additional predictors that emerged across languages. For English, RAN explained additional variance in the English monolinguals suggesting that RAN has both direct and indirect effects (via decoding) on reading comprehension in this group. In contrast, switching emerged as an additional predictor for the Greek monolinguals. For the bilinguals, switching predicted a small amount of unique variance over and above the other variables, while visuospatial WM and updating were found to explain a considerable amount of additional variance in Greek. Thus, the results are in line with the suggestion that bilinguals rely more on EF skills to compensate for their lower language proficiency. Note that the relatively large contribution of visuospatial WM in the bilinguals (9.4%) parallels the findings for word reading in suggesting a crucial role for WM skills in bilingual reading development.

In the current study, the independent contribution of oral skills to reading comprehension was relatively small, especially in the two monolingual groups (<10%). This suggests that the measures used to gauge oral language skills (expressive vocabulary and sentence repetition) do not capture the full range of oral language skills that are implicated in reading comprehension. Accordingly, it has been argued that the amount of variance explained by linguistic comprehension depends heavily on how these skills are measured (e.g., Wong et al., 2017). This is an important issue that needs to be taken into consideration when comparing results across different studies. Moreover, it is unclear whether the differences between monolinguals and bilinguals in terms of the relative contribution of the various component skills is due to the bilingual children being at an earlier stage in their reading development, or due to different reading strategies altogether. Longitudinal data are needed to see how stable the predictors of word reading and reading comprehension are in bilinguals over time. Finally, it is likely that reading strategies differ as a function of reading ability, as pointed out by Johnston and Kirby (2006), so future research could examine the interactions between the component skills and reading ability.

Biliteracy & oral language skills

The results from the group comparisons showed differences in favour of the monolinguals on all measures of oral language skills, with the exception of story comprehension in English, where the bilinguals performed on a par with monolinguals. Moreover, the crosslinguistic comparison of the bilingual children's narrative skills across the two languages showed no differences in story length or syntactic complexity. This suggests that the bilingual children's performance in Greek was higher than what could have been expected on the basis of their vocabulary and morphosyntactic skills, although there was no monolingual data to support this claim. The link between oral language skills (vocabulary, listening comprehension) and reading comprehension is well established, and several studies have found that children's early narrative production predicts reading comprehension longitudinally (e.g., Dickinson & Tabors, 2002; Griffin et al., 2004; Miller et al., 2006). Moreover, previous research suggests that the relationship between oral language and reading skills is likely to be reciprocal (e.g., Sears & Keogh, 1993; Verhoeven et al., 2011; Vivas, 1996). Thus, it was reasoned that literacy development interacts with oral language skills, so that biliteracy is associated with balanced language proficiency (i.e., similar levels of linguistic skills across the two languages). This would result in higher levels of between-language competition which has been argued to lead to enhancements in executive control abilities. Alternatively, it was hypothesized that literacy input in either language supports processing of decontextualized language, e.g., through increased knowledge of story structure. The results in chapter 5 revealed positive effects of biliteracy on children's oral language skills in Greek. More specifically, the two performance-based indices were found to explain a small, but significant amount of variance in SRT accuracy scores over and above age, non-verbal IQ, bilingual input at home, and vocabulary. In addition, there were significant effects of BIS2 scores on all three SRT scores in Greek, but the influence was in the opposite direction, i.e., children with lower levels of biliteracy across the two languages reached higher scores on the SRT in Greek. The significant negative effects of BIS2 are most likely due to some confounds arising from the calculation of the indices (e.g., skewed distributions of schooling indices). The positive association between the performance-based indices and SRT accuracy in Greek supports the hypothesis that biliteracy positively impacts children's EF skills, and working memory in particular. Because of the high correlation between BIR1 and BIR2, it is unclear whether the effect is due to balanced biliteracy across the two languages or due to overall higher levels of biliteracy across the two languages. Future research is needed to distinguish between the two possibilities. The fact that no significant effects of biliteracy were found for SRT accuracy in English might be due to a lack of individual variation in this measure. Alternatively, it is possible that for bilinguals, sentence repetition in the dominant language is less demanding, and thus, does not implicate verbal WM to the same extent as sentence repetition in the minority language does. Thus, the results regarding the relationship between biliteracy and oral language skills suggest selective effects for measures that tap into executive functions skills. Future research investigating possible biliteracy effects on narrative skills at the macrostructure level might provide further evidence in support of the link between biliteracy and measures of oral language skills that pose high demands on executive functions.

Biliteracy & executive functions

The group comparisons for measures of executive function skills indicated selective advantages for bilinguals in verbal WM when differences in vocabulary were accounted for. Moreover, there was a tendency for bilinguals to score higher than the monolinguals on letter fluency in English, but only when differences in vocabulary were controlled for. In contrast, no bilingual advantage was observed for letter fluency in Greek, updating and non-verbal EF measures (i.e., visuospatial WM, inhibition, switching). In fact, the Greek monolinguals were found to outperform the bilinguals on the measure of inhibition. The superior performance on part of the Greek monolinguals on the inhibition measure is consistent with previous studies showing that a multitude of experiences and factors, such as SES, playing video games, musical training and physical exercise, can boost executive function skills (see Valian, 2015). The fact that experiences other than bilingualism can affect executive function skills, as well as the inconsistent findings across studies suggest that inhibitory control is insufficient in explaining the mechanisms that drive the bilingual advantage in executive function skills (Hilchey & Klein, 2011). Hence, further research is required to determine which aspects of the bilingual experience influence cognitive abilities while taking into account other non-linguistic variables that have been shown to affect cognitive performance. One step in this direction has been done by researchers that looked at the effects of code-switching behaviour on cognitive control in bilinguals. The results from these studies identify language-switching as one of the possibly many aspects of the bilingual experience that enhance non-linguistic executive control (Hofweber et al., 2016; Prior & Gollan, 2011; Verreyt, Woumans, Vandelanotte, Szmalec & Duyck, 2015). Biliteracy is another aspect of bilingualism that is likely to have positive effects on executive function skills. Some initial evidence for this claim comes from a study by Bialystok and Barac (2012) who found that time spent in a bilingual education programme was positively related to performance on executive control tasks. The authors argued that the bilingual advantage in cognitive control emerges with accumulating experience in a bilingual environment rather than by bilingualism per se. However, it is possible that the bilingual advantage observed in Bialystok and Barac's (2012) study is at least partly due to the children acquiring literacy in two languages. This possibility was explored in the present study by using different measures of biliteracy to predict children's performances on a range of executive function tasks. The hypothesis that biliteracy has positive effects on executive function skills was based on the premise that biliteracy is associated with balanced bilingual proficiency, and that children with more balanced bilingual proficiency experience higher levels of between-language competition due to stronger representations and more overlap between the two languages. The results from chapter 6 showed no positive effects of biliteracy on non-verbal measures of executive function skills. In contrast, a positive impact of biliteracy was observed for updating, as well as for verbal WM in English and Greek. Thus, children with balanced biliteracy and overall higher levels of biliteracy across the two languages scored better than children with lower levels of biliteracy. The finding that biliteracy predicted performance on the working memory task also fits in nicely with the significant association between biliteracy and SRT accuracy in Greek (see chapter 5), since sentence imitation is thought to tap into working memory as well. Notably, the effects were obtained for both the purely relative index (BIR1) and for the index that incorporated balance and actual level simultaneously (BIR2). This is consistent with the view that cognitive enhancements in bilinguals arise due to increased between-language competition as a result of balanced bilingualism/biliteracy, but that the effects only emerge when a certain threshold of bilingual proficiency is achieved (see Threshold Hypothesis by Cummins, 1976, 1979). The observed positive association between biliteracy and updating skills corroborates findings by Marinis et al. (under review) where balanced bilingual education was found to predict 2-back scores. However, in Marinis et al. (under review), biliteracy was measured on the basis of amount of formal instruction received in the two languages, while in the current study the effect only emerged for the performance-based indices, but not for indices based on amount of schooling. In fact, the results for the schooling-based indices obtained in the current study point to the possibility that these measures were confounded by some other exposure related variables. In addition, Marinis and colleagues did not find similar effects of balanced bilingual education on digit backwards scores. Finally, Bialystok and Barac (2012) reported effects of bilingual schooling (i.e., time spent in an immersion program) on inhibition skills, whereas the current study did not reveal any links between biliteracy and the measure of inhibition. Thus, the mixed findings suggest that performance- and experience-based measures of biliteracy show different patterns of relationships with executive function measures. While the significant association between biliteracy and verbal WM skills is consistent with the results from the group comparisons where the bilinguals were found to outperform the monolinguals (after controlling for differences in vocabulary), there was no evidence for a bilingual advantage in updating skills on the basis of the group comparisons. The results from the regressions in chapter 6 showed that the effect of biliteracy was slightly larger for the verbal WM measures than for updating (Greek WM: 12%, English WM: 10%, updating: 8%). This suggests that the effect of biliteracy on verbal WM was strong enough to be detected at the group level despite the large individual variation in the bilingual sample, while the effect on updating was too small to emerge in the group comparisons. Thus, the results stress the need to treat bilingualism and biliteracy as continuous variables since subtle effects of the bilingual experience might not be detectable in group designs due to the high level of heterogeneity inherent to the bilingual population.

Vocabulary and verbal working memory in bilinguals

A particularly prominent finding of the current study was the pivotal role of vocabulary for the development of oral language and literacy skills. The group comparisons revealed large gaps between bilinguals and monolinguals in expressive vocabulary in both languages, but even more so in the minority language Greek. Moreover, for all measures that showed group differences in favour of the monolinguals, the effect disappeared when vocabulary scores were used as a covariate in the analyses, with the exception for letter fluency in Greek, where the difference persisted even after controlling for differences in vocabulary. This suggests that vocabulary is responsible for bilingual children's lower performance on measures of oral language and literacy skills. The pervasive effect of vocabulary on bilingual children's performances has been reported in numerous studies and thus, constitutes a robust finding (e.g., Bialystok et al., 2008; Blom et al., 2017; Komeili & Marshall, 2013; Luo et al., 2010). Moreover, the large influence of vocabulary on oral language and literacy skills was further evidenced in the regression analyses in chapters 4 and 5. The fact that oral language measures differ in the extent to which they implicate lexical skills, needs to be taken into consideration in bilingual assessments.

The second prominent finding of the current study pertains to the role of verbal WM in bilingual performance. A bilingual advantage in verbal WM was observed in the group comparisons when vocabulary was included as a covariate in the analyses. Moreover, the patterns of predictors for word reading showed that verbal WM made larger contributions in the bilinguals than in the monolinguals in both languages. For reading comprehension too, the results showed additional significant contributions of measures tapping WM for the bilinguals in Greek, but not the monolinguals. Finally, biliteracy, as measured by performance on word reading tasks in the two languages, was found to predict performance on measures of verbal WM in both English and Greek. The fact that the effects for verbal WM were observed in both languages, as well as the finding that the bilingual children's performance did not differ across languages support the view that verbal WM skills reflect a general ability to process language, rather than a language-specific skill (Gutiérrez-Clellen, Calderén & Weismer, 2004). Importantly, the results for the decoding measure in the majority language English point to the possibility that the bilingual children can compensate for their lower lexical abilities by relying more on verbal WM to achieve monolingual levels of word reading skills. The group comparisons in chapter 2 showed that the bilinguals were able to perform on a par with their monolingual peers on English word reading, despite their lower vocabulary skills. Moreover, both vocabulary and verbal WM made substantial contributions to word reading in English, which is consistent with the claim that bilingual children's lower vocabulary skills and superior verbal WM abilities cancel each other out. Similar arguments could be made to explain the bilingual children's performance on the letter fluency task in English, namely that the bilingual children's lower vocabulary and superior WM skills cancelled each other out leading to equal performance by the two groups. In line with this suggestion, letter fluency showed moderate correlations with both vocabulary and verbal WM scores. However, no such 'compensatory effects' were observed for the sentence repetition task, which implicates both linguistic and executive function skills (i.e., working memory). Bilinguals were found to score lower on this task than their English monolingual peers, even when alternative scoring methods were used to try to reduce the lexical requirements of the task. This suggests that the linguistic demands were too high for the bilinguals to be able to compensate for their lower lexical skills by their enhanced WM abilities. A crucial difference between the sentence repetition and the letter fluency task is that sentence repetition taps specific vocabulary items, while letter fluency does not. This might explain why the bilingual children's performance on letter fluency in English was not hampered by their smaller vocabularies, in contrast to sentence repetition. However, for the minority language Greek, the gap in lexical skills is too big to be compensated for by working memory skills. Hence, the bilingual children were found to perform lower than their monolingual peers on all oral language and literacy measures in Greek (with the exception of the lexicality effect). Although the results from chapter 6 showed significant effects of biliteracy on verbal WM skills in English and Greek, no conclusions can be made regarding the directionality of the effect. This is because developing literacy in two languages might boost children working memory skills, but it is also possible that children with better working memory skills reach higher levels of biliteracy. In fact, it is highly probable that working memory and literacy skills form a reciprocal relationship, similar to what has been argued for the link between oral language and literacy skills. In the current study, a measure of bilingual input at home was included in the analyses in chapters 5 and 6 in an attempt to disentangle biliteracy effects from bilingualism effects. Although the current findings did not point to bilingualism as the source of the children's superior WM skills, more stringent measures are needed to confirm that the biliteracy effects observed in the current study were not simply bilingualism effects.

Measuring biliteracy

Research on bilingualism and biliteracy is muddied by methodological and conceptual issues (Grosjean, 1998). Studies on the effects of bilingualism and biliteracy often use group designs, thereby treating bilingualism and biliteracy as categorical variables. However, bilinguals show vast differences in their language learning experiences, and the need to use quantitative measures of bilingualism has long been recognized (Grosjean, 1998). Accordingly, there is a growing number of studies that try to relate particular aspects of the bilingual experience with linguistic and cognitive outcomes. Despite these advances, the fact that there are no commonly agreed measures of bilingual proficiency continues to be a major issue in the field (Bedore et al., 2012). The situation for biliteracy is not much different. Given the lack of established measures of biliteracy, the present study sought to examine the validity and usefulness of two types of biliteracy indices, one based on performance on a word reading test in the two languages (BIR), and one based on amount of schooling in the two languages (BIS). Moreover, two different formulae were used for each type of index, one that calculates biliteracy strictly in terms of the degree of balance across the two languages, and one that incorporates information on both actual levels of biliteracy and balance, although actual levels carry much more weight in the calculation than balance. Previous studies have shown that performance- and experience-based measures result in different classifications of language dominance and bilingual proficiency (Bedore et al., 2012). In the current study, positive effects of biliteracy were observed for performance-based indices, but not for the experience-based indices. In fact, the results showed significant contributions of BIS1 to visuospatial WM and letter fluency in English, as well as significant effects of BIS2 on SRT scores in Greek. However, the observed effects for BIS1 and BIS2 went in the opposite direction from what was expected, with children towards the ‘monoliterate’ end of the spectrum outperforming children with higher levels of biliteracy. These findings are difficult to interpret. Admittedly, it is possible that the effects are artefacts resulting from an uneven distribution of scores. For example, the results for BIS1 might be driven be the amount of schooling in English in that children with higher amounts of schooling in English also tended to be more unbalanced resulting in higher BIS1 scores. Similarly, the results for BIS2 might be due to the fact that children with overall more instruction in the two languages were older and thus, might show stronger language dominance in favour of English than younger children. This highlights the need to validate the proposed indices of bilingualism and biliteracy through more elaborate statistical procedures to ensure that they provide an accurate measure of the construct.

Another issue with the experience-based indices might be that they calculate biliteracy on the basis of amount of instruction without distinguishing between CLIL (Content and Language Integrated Learning) and more traditional language classes. Instruction at mainstream primary schools involves almost exclusively CLIL, while the instruction provided by Saturday schools is better describes as traditional language classes. Thus, children who had received some formal instruction in Greece before coming to the UK, and children who had attended the Greek primary school in London are likely to have had more exposure to CLIL in Greek than children who acquired Greek literacy through Saturday schools. Moreover, it has been argued that CLIL leads to better linguistic outcomes than traditional language classes (Dalton-Puffer, 2008; Jiménez Catalán & Agustín Llach, 2017; Lasagabaster, 2011). Thus, the BIS indices calculated in the current study may not be an accurate reflection of children's levels of biliteracy because of differences in the effectiveness of CLIL and non-CLIL classes. Although the current study did not find any evidence for biliteracy effects in terms of amount of schooling in the two languages, the results for the BIR indices together with findings from previous studies suggest that the two types of measures show differential relationships with different EF measures. It is possible that the more global indices based on experience show stronger relationships with more complex tasks (e.g., 2-back, inhibition measures), while the more one-dimensional performance-based indices are associated with simpler tasks, such as the digit backwards task. Developing measures of bilingualism and biliteracy remains a tall task and more research is needed to establish reliable measures that can be used across different bilingual populations and research fields.

7.3 Practical implications

Parents of bilingual children are often faced with the question of how to best support their child's language development in order to achieve optimal outcomes in both languages. One of the major concerns is the child's academic achievement in the majority language. This is at least partly due to governmental reports and international surveys that tend to find lower performance on part of bilinguals compared to monolinguals. For this reason, families are sometimes pressured into increasing the use of the majority language at home, at the obvious expense of the minority language. As a consequence, the bilingual children do not receive sufficient input in the minority language to further develop and/or maintain their linguistic abilities in that language. Although the current study did not directly assess the impact of input variables on language and literacy outcomes in the majority language, the results from the group comparisons for English suggest that there is little reason for concern regarding children's language skills in the majority language. More specifically, the comparison of monolingual and bilingual children's performances on measures of oral language and literacy skills showed no differences for basic reading skills, story comprehension, letter fluency and verbal working memory. For reading comprehension and SRT scores, there were some small group differences in favour of the monolinguals, which however, disappeared when vocabulary was controlled for. In contrast, there was a marked difference in expressive vocabulary skills with the monolinguals outperforming the bilinguals. Thus, the findings suggest that for the majority language English, the only domain where bilinguals seem to face a continuous challenge is vocabulary. The fact that the bilinguals in the current study performed at monolingual levels on nearly all language and literacy measures in English is quite remarkable given that the sample included children who had been living in the UK for a few years only at the time of testing. Moreover, some of the bilingual children were attending a Greek primary school in the UK, suggesting that even the children who received formal instruction predominantly in Greek were able to catch up with the monolinguals on the various language and literacy measures. For the minority language Greek, the group differences in favour of the monolinguals were more marked, but again the analyses showed that they could all be traced back to the bilingual children's lower lexical skills (with the exception of the letter fluency where the monolinguals outperformed the monolinguals even when vocabulary was controlled for). The pivotal role of vocabulary for oral language and reading skills of bilinguals was evident throughout the study. Not only did lexical skills affect the group differences between monolinguals and bilinguals, vocabulary also showed particularly strong correlations with sentence repetition, rapid naming, decoding and reading comprehension. More importantly, lexical skills made substantial contributions to sentence repetition and reading skills in both languages. For sentence repetition, vocabulary accounted for about 25% of the variance in English and for about 50% in Greek. This shows the close association that exists between lexical skills and grammatical abilities suggesting that good vocabulary knowledge is a prerequisite for processing oral language input. Lexical skills are even more crucial for reading as they contribute to both word reading and reading comprehension. In line with this, the results of the current study showed that in both languages, vocabulary accounted for approximately 20% of variance in word reading. Moreover, oral language skills, as measured by expressive vocabulary and sentence imitation, together explained about 50% of the variance in reading comprehension in both languages. Thus, lexical skills support reading comprehension via multiple processes, namely by contributing to word decoding and broader oral language skills (i.e., SRT), but also by providing relevant knowledge and schemas required to construct an understanding of the text. Consequently, attempts to support bilingual children's language and literacy skills in either language should focus primarily on lexical skills, for example through interventions that specifically target vocabulary development. This is because knowing a word involves more than just knowing its meaning. Rather, lexical knowledge includes information about the morphological structure of a word as well as its use in context (part of speech, register, connotations, collocations, etc.), among other things. Thus, interventions that focus on lexical development inadvertently also boost grammatical abilities since new words are typically encountered in context, rather than in isolation. Moreover, improving children's lexical skills allows them to allocate more of their cognitive resources to higher-level processes during comprehension and production. For example, it is likely that the bilingual children's depressed performance on the SRT in the current study was not due to vocabulary as such, but rather due to slower and more effortful lexical processing so that less attention could be paid to the grammatical properties of the sentence resulting in less accurate recall. The multidimensionality of vocabulary knowledge is also the reason why lexical skills assume such a central role in literacy development as evidenced by the substantial contributions of vocabulary to word reading and reading comprehension found in the current study. On the one hand, vocabulary is needed to provide the meanings of the individual words. On the other hand, lexical skills support both low-level reading skills and higher-level processes implicated in text comprehension. At the level of decoding, lexical skills speed up word recognition by facilitating phonological, morphological or orthographic processing, thus allowing for more fluent reading. At the level of reading comprehension, vocabulary knowledge positively affects grammatical processing, as well as the construction of schemata and text models which are essential for the integration of relevant background knowledge. As a consequence, interventions need to take into account the multiple dimensions of lexical knowledge by targeting both vocabulary breadth and depth. Importantly, lexical skills can also be fostered by literacy-based interventions, since reading development and vocabulary skills form a reciprocal relationship. These kinds of interventions involve teaching of word-learning strategies that children can employ when encountering unfamiliar words in texts. Thus, teaching children these strategies will directly improve their reading skills, but also provide them with tools to acquire new vocabulary, which in turn, will feed back into reading comprehension. While these sorts of interventions are typically used to improve bilingual children's lexical skills in the majority language, the close relationship between vocabulary and reading implies that formal instruction in the minority language will result in better oral language skills and possibly also better minority language maintenance.

7.4 Methodological issues

One of the central problems in cross-linguistic research and studies comparing language skills in the two languages of bilinguals is task equivalence. This refers to the fact that it is difficult to perfectly align tasks across two languages due to structural differences. In the present study, the tasks were selected and designed to be as similar and comparable as possible. Some of the tasks used the exact same stimuli in English and Greek, i.e., they were simply translations of each other. However, other tasks used different stimuli in English and Greek (e.g., lexical decision, sentence repetition, word reading) which suggests that these measures are not necessarily comparable in terms of level of difficulty. Moreover, the choice of standardized materials to assess language and literacy skills in relatively understudied languages is often limited. Due to the restricted number of standardized tests of reading skills available in Greek, the English and Greek reading comprehension measures used in the current study differed in important ways. The English measure covered a larger span of reading ability and used open-ended questions allowing for a more precise assessment of reading comprehension skills. In contrast, the Greek reading measure only included three different levels and did not cover very low levels of reading ability so that some of younger bilingual children could not be administered the task. Moreover, the test uses multiple-choice questions which arguably reduce task demands. In order to get a full picture of bilingual children's language and literacy skills in both languages it is paramount to use equivalent measures across languages for maximum comparability. Future research should aim at developing more standardized tests of essential language and literacy skills in multiple languages to facilitate cross-linguistic comparisons. Consequently, the present findings with regard to reading comprehension need to be confirmed in future studies that use reading comprehension assessments of the same format across languages.

Unfortunately, the different format of the reading comprehension tests in the two languages made it impossible to use this measure to calculate performance-based indices of biliteracy. Instead the biliteracy indices that were based on children's performance were computed using a measure of word reading ability which is seen as a low-level skill, and might therefore not be an accurate reflection of children's more global reading skills (i.e., reading comprehension, which is the ultimate goal of reading). Previous research has shown that word reading is acquired relatively easily in languages with transparent orthographies even when oral language skills are relatively low (Geva & Siegel, 2000). Moreover, some studies have found that word reading and reading comprehension are only weakly related in the higher elementary grades (Scarborough, 1998). Thus, using the bilingual children's scores on word reading in Greek may have led to an overestimation of their actual literacy levels. Although the correlational analyses in chapter 4 revealed strong associations between performance on the word reading and reading comprehension task for the bilinguals in both languages (r >.63), the correlations were far from perfect. Hence, it is possible that biliteracy indices that are calculated on the basis of performance on reading comprehension tests might yield different results than the ones obtained in the current study. Improvements could also be made to the experience-based biliteracy indices, for example by obtaining more detailed information on the curriculums of the schools to more accurately calculate the amount of instruction received in each language.
Moreover, schooling is for the most part compulsory resulting in relatively little individual variation which might be problematic when trying to relate amount of schooling in two languages with linguistic and cognitive measures. The majority of the bilingual children in the current sample were enrolled at English mainstream primary schools and received additional instruction in Greek by attending heritage language classes (i.e., Saturday schools). Thus, amount of formal instruction in Greek is the primary source of variation in biliteracy for this group of children. However, because Saturday schools are not compulsory, children may differ in terms of how regular they attend these classes. In the current study, no information was elicited regarding the regularity of attendance at these classes throughout the years. This may have led to imprecisions in the estimation of the amount of schooling received in the minority language Greek. On a related note, the experience-based indices did not take into account differences in instructional approaches across different types of schools. More specifically, instruction received at mainstream primary schools (including the Greek school in London) involves large amounts of CLIL, while instruction at Saturday schools more closely resembles the format of traditional foreign language classes. It has been argued that CLIL leads to better

language outcomes than the more traditional language classes (Dalton-Puffer, 2008; Lasagabaster, 2011). Hence, it may be necessary to distinguish these two types of schooling when estimating levels of biliteracy to avoid confounds in terms of the quality or format of instruction. Although formal schooling is undoubtedly the major source of literacy instruction and reading practice, large individual differences can be expected in terms of the frequency of book reading during free-time. Moreover, literacy practices at home have been found to show strong association with reading development in both monolingual and bilingual children (Leseman et al., 2007; Sénéchal & LeFevre, 2014). This highlights the need for measures of (bi)literacy to encompass multiple dimensions of literacy practices, such as amount of schooling, frequency of free and shared book reading, number of children's books at home, etc. Measuring bilingual experience is notoriously difficult and there seems to be little consensus among researchers how to best capture the relevant factors. Nevertheless, researchers investigating the relationship between input variables and linguistic outcomes have made significant advances in developing comprehensive questionnaires and proficiency indices that incorporate multiple dimensions of the language learning experience (Paradis, 2011; Unsworth, 2013). Thus, one step forward in the research on biliteracy would be to develop more comprehensive and refined questionnaires about literacy input and practices, modelled after the questionnaires targeting language input.

Another caveat of the present study is that some of the measures might have led to ceiling effects. This is particularly problematic for correlation and regression analyses because the lack of variation that accompanies ceiling performance makes it difficult to detect smaller effects in the data. For example, the expressive vocabulary tests were originally designed for monolingual children up to the age of 8;6 leading to possible ceiling effects in the monolingual control groups as well as in the dominant language of the bilinguals (i. e., English). Despite the apparent 'inadequacy' of the vocabulary measures for some of the children, a test of expressive vocabulary was preferred over a test of receptive vocabulary, as the former shows stronger relationships with reading and pre-reading skills than the latter (Chiappe et al., 2004). Ceiling effects might have also been present in the measure of listening comprehension. The purpose of the comprehension questions was two-fold, to probe children's understanding of the stories, but also to provide them with a rough scaffold that would help them tell a coherent narrative. Recall that the age range of the sample was rather wide (between 7 and 12 years) which means that the stories had to be fairly simple to make sure they are appropriate for the younger children. Moreover, it was anticipated that some of the bilingual children would have very low proficiency in the minority language so the simplicity of the stories allowed all of the children to complete the task. It is very common for bilinguals to present large gaps between their receptive and expressive (productive) language skills, especially in the minority language (Gibson et al., 2012; Gibson et al., 2014). Consequently, for English, the listening task and subsequent comprehension questions might have been too easy for the children leading to a possible ceiling effect and a lack of individual variation. Hence, it might be preferable to probe listening comprehension skills and narrative abilities with independent tasks.

On the other hand, the task demands of the Global-Local task might have been too high to accurately measure the children's inhibition and switching abilities. Although overall accuracy in all three groups was fairly high at over 93% correct, there were large variations in reaction times both within and between subjects, with response times frequently exceeding 3 seconds[54]. To reduce the influence of outliers, the analyses were based on median RTs rather than mean RTs. Despite this, both the congruency effect and the switching cost were associated with unusually large standard deviations. There are several factors that may have led to the excessively long reaction times. For example, the version used in the current study required children to respond to four different stimuli (i.e., circles, crosses, triangles, and squares). In contrast, previous studies that employed the Global-Local task with younger children (6 to 10-year-old) have used versions where the children had to respond to two stimuli only (e.g., shapes and circles), which clearly reduces the task demands (Bialystok, 2010; Iarocci, Burack, Shore, Mottron & Enns, 2006). Another factor that might have skewed the results is the number of trials per experimental block. In the present study, each block consisted of 64 trials, whereas in other studies the experimental blocks included considerably fewer trials. For example, in Iarocci et al. (2006) the task consisted of 3 blocks containing 40 trials each, while the version administered in the study by Bialystok (2010) included 16 blocks containing 12 trials each. Thus, the length of the experimental blocks in the current study may have compromised children's investment in the task, thereby increasing the amount of measurement error. Hence, the results for the measures of inhibition and switching obtained in the present study may have been skewed by the high task demands, thereby obscuring possible effects of bilingualism or biliteracy.

7.5 Future directions

The present study offers a number of interesting findings on which future studies on bilingualism and biliteracy can build on. For example, the results from chapter 4 suggest that the bilingual children were able to compensate for their lower vocabulary skills by relying on their enhanced working memory skills to read at monolingual levels. The fact that the bilinguals also showed larger contributions of verbal WM in the minority language compared to their monolingual peers indicated that this might be a bilingual compensation strategy. Thus, future research could focus on the particular reading strategies employed by monolingual and bilingual readers who exhibit different skill levels. The crucial difference between reading and listening comprehension is that the content of written text remains available for re-inspection, while

[54] Note that some researchers code trials with response times above a certain cut-off point (e.g., >3000ms) as errors (e.g., Hayward et al., 2012).

speech content does not. According to Kirby and Savage (2008), this leaves much room for the use of different strategies in order to extract the meaning of the text. The use of such strategies relies on metacognitive abilities, which bilingual speakers are claimed to excel in (Barac, Bialystok, Castro & Sanchez, 2014). The fact that the gap between monolingual and bilingual children is considerably larger for oral language skills than for reading comprehension, with decoding abilities being no different across groups (see Melby-Lervåg & Lervåg, 2014), suggests that the bilinguals somehow are able to (at least partly) compensate for their lower oral language skills, possibly by their enhanced cognitive and metacognitive skills. Thus, bilingual children might use more efficient reading strategies to cope with their limited language proficiency. One way to test this idea is by exploring the reading strategies employed by monolingual and bilingual speakers by looking at their reading-behaviour as reflected by eye-movements (e.g., Martin et al., 2013).

On a related note, future research could investigate the role of orthographic transparency in the bilingual children's minority and majority languages for reading development. On the one hand, phonological awareness and decoding skills have been shown to be transferable across languages in bilinguals (e.g., Durgunoğlu et al., 1993; Melby-Lervåg & Lervåg, 2011). On the other hand, Ziegler and Goswami (2006) argue that monolingual children employ different reading strategies as a function of orthographic transparency. Hence, it is possible that the acquisition of literacy skills in a transparent orthography (e.g., Italian, Greek) is particularly beneficial for reading development in a language with less consistent letter-sound mappings (e.g., English). In line with this, D'Angiulli et al. (2001) found suggestive evidence that exposure to a language with consistent grapheme-phoneme correspondences like Italian supports phonological skills in English. This hypothesis can be confirmed in future studies that compare reading development of bilingual children acquiring (bi)literacy in different language pairs. Moreover, studies with larger samples could apply more advanced statistical methods to investigate whether there are any interactions among the predictor variables that would indicate differences between skilled and less-skilled bilingual readers in terms of the relative contributions of underlying skills. It has been suggested that cross-linguistic transfer of skills requires a certain level of proficiency in both languages (Cummins, 1976, 1979). Thus, children with good levels of proficiency in both languages are likely to use different reading strategies than children with only limited proficiency in one of the two languages.

Another possibility is that the larger contribution of verbal WM in the current sample of bilinguals reflects a less 'advanced' reading strategy, in that reading processes are not fully automatized yet (or less automatized than in the monolingual children). This might also explain why RAN was a better predictor of word reading in the monolingual groups. Although the bilinguals performed on a par with the English monolinguals on word reading accuracy, it is possible that the groups differed on reading fluency, which was not assessed in the current study. The role of fluency in different groups of monolingual and bilingual readers is a promising area for future research since recent studies suggest that reading fluency plays a crucial role in reading comprehension, especially in higher grades where individual differences in decoding accuracy tend to level out (Language & Reading Research, 2015).

In the current study, the bilingual children were found to perform on a par with their monolingual peers on the literacy measures in the majority language English, with the exception of a small group difference in favour of the monolinguals for reading comprehension. While this indicates that the bilingual children are in the process of 'catching up' with the monolinguals on English reading comprehension, longitudinal data is needed to confirm that bilinguals are able to eventually reach monolingual levels. This would provide further evidence for the long-term benefits of biliteracy for reading development in the bilingual children's majority language (see also Montanari, 2014; Oller & Eilers, 2002).

The results of the present study suggest that biliteracy is an important variable to consider in the study on bilingualism. Moreover, the results from chapters 5 and 6 indicate that performance-based measures of biliteracy are able to account for additional variance in executive function and oral language skills. In contrast, no positive effects were observed for the schooling-based indices. It is likely that the experience-based measures of biliteracy used in the current study did not provide an accurate reflection of the children's literacy skills in the two languages. A potentially crucial factor that needs to be considered in future studies is the children's reading practices during leisure time. Thus, researchers could try to develop experience-based measures of biliteracy that take into account amount of schooling, as well as literacy practices during free-time. Similarly, the measure of bilingual input at home (calculated as the difference in the relative amount of input in the two languages in the home environment) did not show any associations with the oral language measures in the current study. It is possible that the lack of a relationship between bilingual input and oral language measures is due to the relatively little output the children produce in Greek. There is mounting evidence that language output is another crucial factor in bilingual language development (e.g., Bohman et al., 2010; Unsworth, 2016). Accordingly, De Cat and Serratrice (2017) have developed a composite measure of language experience (Bilingual Profile Index) that combines information on children's language input and output. Importantly, De Cat and Serratrice (2017) found that the Bilingual Profile Index was a reliable predictor of children's performances on a range of oral language measures. Thus, future research could try to develop a similar index for biliteracy, where input is reflected by formal literacy instruction, and output is conceived as literacy practices during leisure-time.

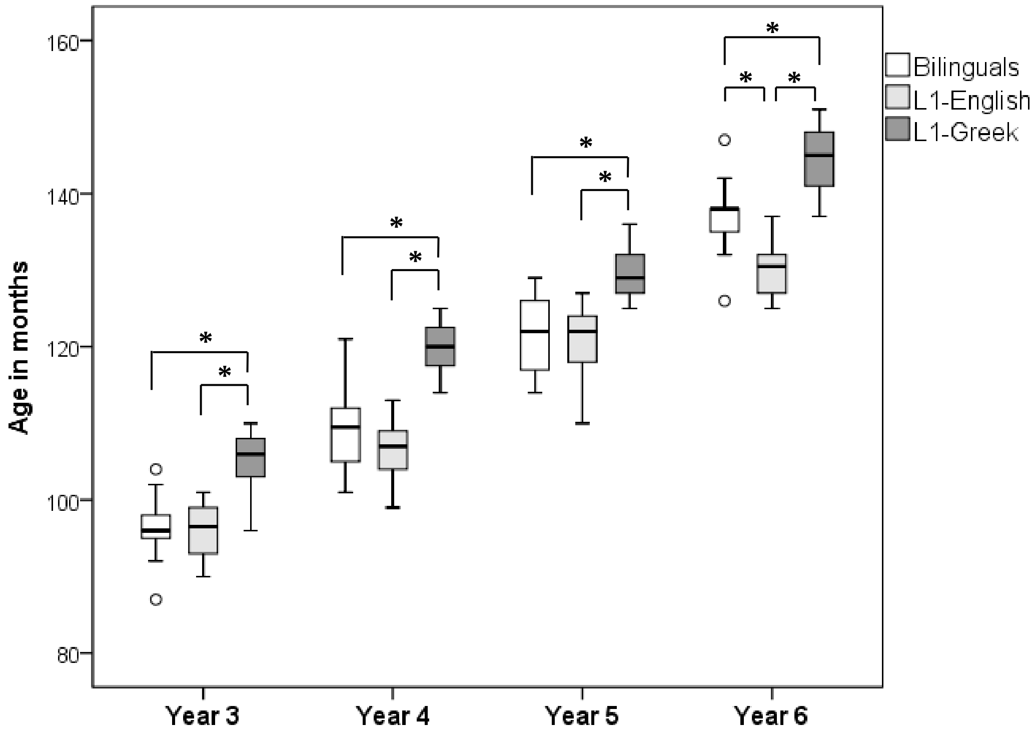
7.6 Conclusions

The present study on the development of biliteracy in bilingual children adds to previous research by providing a comprehensive assessment of the bilingual children's language and literacy skills in both of their languages, English and Greek. A strength of the current study is that the bilingual group included children from a wide range of different language experiences which is representative of the Greek-English bilingual population in the UK. The results showed that group differences in performance on oral language and literacy measures are largely attributable to the bilingual children's lower vocabulary skills. Thus, vocabulary is the only domain that poses a continuous challenge for bilinguals. On the other hand, bilinguals were found to outperform monolinguals on verbal working memory in both languages. The findings further indicated that the bilingual children use their enhanced working memory skills to compensate for their lower lexical abilities to achieve monolingual levels on measures of basic reading skills, and possibly also to reduce the gap in reading comprehension. Accordingly, the results showed that verbal WM accounted for more variance in word reading in bilinguals, whereas RAN was a better predictor of basic literacy skills in monolinguals. Importantly, the pattern was found for both the majority and the minority language, suggesting that this reflects a bilingual strategy rather than a less advanced stage in reading development. Finally, the study provided evidence that biliteracy might be one of the crucial factors that drives the bilingual advantage in executive function skills. Thus, the present results are in line with the claim that the development of bilingual proficiency is associated with enhancements in executive function skills, and point to the potential role of developing literacy in the minority language.

APPENDICES

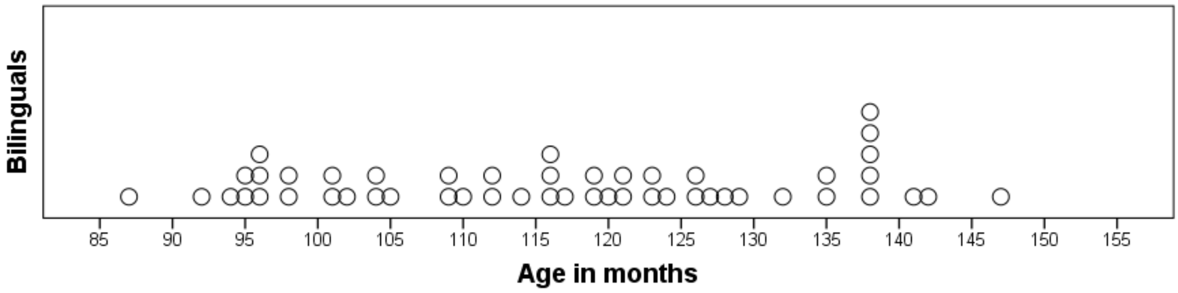
APPENDIX A

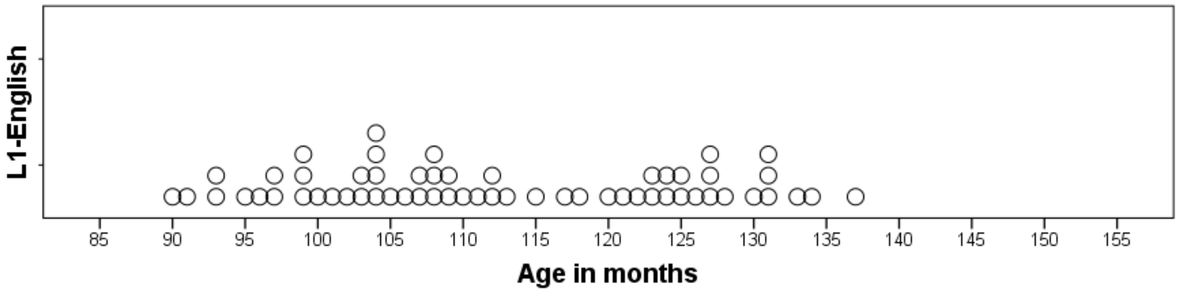
Boxplot for age in months per language group and Year level.

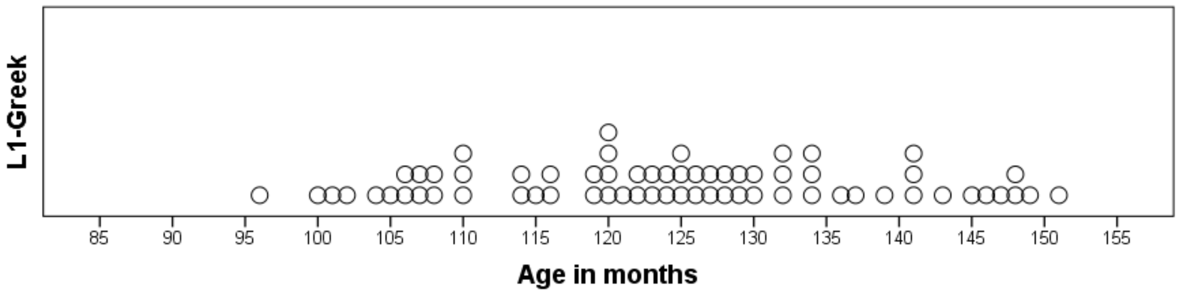


APPENDIX B

Distribution of age in months for the three language groups. Each circle represents one child (bilinguals: n=50; L1-English: n=58; L1-Greek; n=66).







APPENDIX C

Parental questionnaire used to obtain background information on the bilingual children's home and school environments.

Questionnaire for Parents

PART A:
PARENTS' LANGUAGE ABILITY & USE

A1 Which language or languages do you speak with these people? *(Please tick the boxes!)*

	English only	*more English than Greek*	*both languages equally often*	*more Greek than English*	*Greek only*
With my partner I speak	☐	☐	☐	☐	☐
With my child I speak	☐	☐	☐	☐	☐
With Greek relatives and friends living in the UK I speak	☐	☐	☐	☐	☐
With other Greek speaking people living in the UK I speak	☐	☐	☐	☐	☐

A2 Do you use any dialect at home? If so, which one? ____________________________

A3 How would you assess your language skills in Greek? *(Please tick the boxes!)*

I can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand Greek when I hear other Greeks speaking to one another.	☐	☐	☐	☐	☐
… understand Greek when I watch TV	☐	☐	☐	☐	☐
… speak Greek	☐	☐	☐	☐	☐
… read Greek	☐	☐	☐	☐	☐
… write Greek	☐	☐	☐	☐	☐

A4 **How would you assess your partner's language skills in Greek**? *(Please tick the boxes!)*

He/she can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand Greek when he/she hears other Greeks speaking to one another.	☐	☐	☐	☐	☐
… understand Greek when he/she watches TV	☐	☐	☐	☐	☐
… speak Greek	☐	☐	☐	☐	☐
… read Greek	☐	☐	☐	☐	☐
… write Greek	☐	☐	☐	☐	☐

A5 **How would you assess your language skills in English?** *(Please tick the boxes!)*

I can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand English when I hear others speaking English to one another.	☐	☐	☐	☐	☐
… understand English when I watch TV	☐	☐	☐	☐	☐
… speak English	☐	☐	☐	☐	☐
… read English	☐	☐	☐	☐	☐
… write English	☐	☐	☐	☐	☐

A6 **How would you assess your partner's language skills in English?** *(Please tick the boxes!)*

He/she can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand English when he/she hears other English people speaking to one another.	☐	☐	☐	☐	☐
… understand English when he/she watches TV	☐	☐	☐	☐	☐
… speak English	☐	☐	☐	☐	☐
… read English	☐	☐	☐	☐	☐
… write English	☐	☐	☐	☐	☐

A7 **Do you know any other languages apart from English and Greek?** ☐ Yes ☐ No

A7.1 **If so, which one(s)?** ____

A7.2 **Do you use these languages <u>at home</u> with your family members?** ☐ Yes ☐ No

A7.3 **If so, with whom?**

☐ with your parents (if they live with you) ☐ with your partner
☐ with your siblings (if they live with you) ☐ with your children

A8 **Does your partner know any other languages apart from English and Greek?**

☐ Yes ☐ No

A8.1 **If so, which one(s)?** ____

A8.2 **Does he/she use these languages at home with family members?** ☐ Yes ☐ No

A8.3 **If so, with whom?**

☐ with his/her parents (if they live with you) ☐ with you

☐ with his/her siblings (if they live with you) ☐ with your children

PART B: YOUR CHILD'S USE OF DIFFERENT LANGUAGES

B1 **As far as you know, your child's friends are:**

☐ mainly children with Greek parents

☐ mainly children whose parents are from the UK

☐ mainly children whose parents come from other countries (not from the UK)

☐ mainly children whose parents are from the UK and children whose parents are from other countries

B2 **Which languages does your child use with these people?** *(Please tick the boxes!)*

My child speaks…	***English only***	***more English than Greek***	***both languages equally frequently***	***more Greek than English***	***Greek only***
…with me	☐	☐	☐	☐	☐
…with my partner	☐	☐	☐	☐	☐
…with his/her brothers and sisters	☐	☐	☐	☐	☐
…with other children from Greece	☐	☐	☐	☐	☐
…with other Greek speaking relatives and friends who live in the UK	☐	☐	☐	☐	☐
…with other Greek speaking adults who live in the UK	☐	☐	☐	☐	☐

B3 **When you address your child in English and the child replies to you in Greek, you continue the conversation in:**

☐ Greek ☐ English ☐ not applicable

B3.1 **When you address your child in Greek and the child replies to you in English, you continue the conversation in:**

☐ Greek ☐ English ☐ not applicable

B4 **Where has your child attended primary school so far?**

☐ Greece, If so, since what age? ________________

for how long? ________________

which grades? ________________

which language was mainly used at school? ________________

☐ UK, If so, since what age? ________________

for how long ________________

which grades? ________________

which language was mainly used at school? ________________

B5 **Does anyone help your child with his/her homework?** ☐ Yes ☐ No

B5.1 **If so, who is this person?**

☐ me ☐ my partner ☐ older brother or sister ☐ someone else

B5.2 **Which language is used when helping your child with homework?**

☐ mainly English ☐ mainly Greek ☐ both languages

B6 **Does your child use a computer at home?** ☐ Yes ☐ No

[If so, please answer the questions below]

B6.1 **If yes, how many hours per day does your child spend on the computer hearing or using a language, e.g. playing games, exchanging messages (email, chat), reading websites, watching videos or listening to songs?__________________**(hours per day)

B6.2 **Which language(s) does your child use / read / hear on the computer, in general?**

	not at all	*rarely*	*sometimes*	*often*	*very often*
Greek	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐
another language; If so, which one? ________________	☐	☐	☐	☐	☐

B7 **How often does your child communicate in different languages <u>every day</u> (in various circumstances)?**

	not at all	*rarely*	*sometimes*	*often*	*very often*
in Greek	☐	☐	☐	☐	☐
in English	☐	☐	☐	☐	☐
in other languages	☐	☐	☐	☐	☐

PART C:
ACQUISITION & DEVELOPMENT OF YOUR CHILD'S LANGUAGE ABILITY IN GREEK AND PARENTAL EFFORTS IN TERMS OF THE DEVELOPMENT OF GREEK

C1 How would you assess your child's language skills in Greek?

My child can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand Greek when he/she hears other Greeks speaking to one another.	☐	☐	☐	☐	☐
… understands Greek when he/she watches TV	☐	☐	☐	☐	☐
… speak Greek	☐	☐	☐	☐	☐
… read Greek	☐	☐	☐	☐	☐
… write Greek	☐	☐	☐	☐	☐

C2 Does he/she also use English words when speaking Greek?
☐ almost never ☐ rarely ☐ sometimes ☐ often ☐ almost always

C3 How old was your child when s/he first came to regular contact with the Greek language? *(Choose the answer that most closely matches your situation. First tick the boxes on the left and then select or provide the reason why.)*

☐ newborn
- ☐ because you spoke Greek <u>as well as other languages to him/her</u>
- ☐ because you <u>only</u> spoke Greek to him/her
- ☐ because:____

☐ between 1 and 3 years:
- ☐ because you started speaking Greek to him/her
- ☐ because childcare was provided by Greek speakers
- ☐ because:____

☐ after 4:
- ☐ because you started speaking Greek to him/her
- ☐ because he/she went to a Greek kindergarten
- ☐ because:____

☐ after 6:
- ☐ because this is when he/she came to Greece
- ☐ because he/she went to a Greek school for the first time
- ☐ because:____

C4 Were there periods during which your child did not have contact with the Greek language since he/she began to use it? ☐ Yes ☐ No

C4.1 If so, please indicate at what age this happened and for how long.

____

C5 **From how many different people does your child hear Greek?** *(Please tick the appropriate box(es))*

☐ teachers ☐ classmates ☐ relatives ☐ family friends ☐ friends

C6 **Do you try/ Have you tried to help your child learn Greek or improve his/her Greek?** ☐ Yes ☐ No

C6.1 **If so, tick the appropriate box(es) :**

☐ We always try or tried to speak Greek to him/her.

☐ We make sure or made sure that he/she watches Greek TV programs, etc.

☐ We read Greek books to him/her or we used to, when he/she was little.

☐ We make or made sure that he/she reads Greek books.

☐ We help or helped him/her with his/her homework.

☐ He/she has or had additional lessons in Greek.

☐ Other: ____

C6.2 **If your child attends or has attended additional lessons in Greek, please tick the box that explains how this was done.**

☐ My child has or has had additional private Greek lessons.

☐ My child attends or has attended additional Greek classes at school.

C6.3 **If your child takes or has taken additional lessons in Greek at home or in school, please state the length of those lessons:**

- since/for __________ years **or**
- since/for __________ months.

C6.4 **How often does or did he/she attend these lessons?**

The lessons take/took place _______ times a week and last/lasted _______ minutes.

C6.5 **If your child attends or has attended additional Greek lessons, why have you chosen this particular way of support?**

____

____

____

C7 **How does or did your child react to your efforts to help him/her learn Greek?**

☐ very negatively ☐ negatively ☐ indifferently ☐ positively ☐ very positively

C8 **Is it important for you that your child knows Greek ?**

☐ not at all ☐ a little ☐ quite important ☐ very important ☐ absolutely

C8.1 **Why?** *(Please state the most important reasons)*

____

____

____

PART D:
ACQUISITION & DEVELOPMENT OF YOUR CHILD'S LANGUAGE ABILITY IN ENGLISH AND THE PARENTAL EFFORTS IN TERMS OF THE DEVELOPMENT OF ENGLISH

D1 How would you assess your child's language skills in English?

My child can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand English when he/she hears others speaking to one another.	☐	☐	☐	☐	☐
… understand English when he/she watches TV.	☐	☐	☐	☐	☐
… speak English	☐	☐	☐	☐	☐
… read English	☐	☐	☐	☐	☐
… write English	☐	☐	☐	☐	☐

D2 Does he/she also use Greek words when speaking English?

☐ almost never ☐ rarely ☐ sometimes ☐ often ☐ almost always

D3 At what age was your child's first regular contact with the English language? Choose the answer that most closely matches your situation.

☐ newborn
- ☐ because you spoke English as well as other languages to him/her
- ☐ because you only spoke English to him/ her
- ☐ because:____

☐ between 1 and 3 years:
- ☐ because you started speaking English to him/her
- ☐ because childcare was provided by English speakers
- ☐ because:____

☐ after 4:
- ☐ because you started speaking English to him/her
- ☐ because he/she went to a English kindergarten
- ☐ because:____

☐ after 6:
- ☐ because you started speaking English to him/her
- ☐ because he/she went to a English school for the first time
- ☐ because:____

D4 Were there periods during which your child did not have contact with the English language since he/she began to use it? ☐ Yes ☐ No

D4.1 If so, please indicate at what age this happened and for how long?

____

D5 **From how many different people does your child hear English?**

☐ teachers ☐ classmates ☐ relatives ☐ family friends ☐ friends

D6 **Do you do /have you done something to help your child improve his/her English?**

☐ Yes ☐ No

D6.1 **If so, tick the appropriate box(es).**

☐ We always try or have tried to speak English with him/her.

☐ We make sure or have made sure that he/she watches English TV programs, etc.

☐ We read or have read English books to him/her or we used to, when he/she was little.

☐ We make sure or have made sure that he/she reads English books.

☐We help or have helped him/her with his/her homework.

☐ We provide or have provided him with additional English lessons.

☐ Other: ____

D6.2 **If your child attends or has attended additional English lessons, please tick the box that explains how this was done…**

☐ My child has or has had additional private English lessons.

☐ My child attends or has attended additional English classes at school.

D6.3 **If your child takes or has taken additional lessons in English at home or at school, please state the length of those lessons:**

- since/for __________ years **or**
- since/for __________ months.

D6.4 **How often does or did he/she attend these lessons?**

The lessons take/took place _______ times a week and last / lasted _______ minutes.

D6.5 **If your child attends or has attended additional English lessons, why have you chosen this particular way of support?**

____

____

____

D7 **How does or did your child react to your efforts to help him/her learn English?**

☐ very negatively ☐ negatively ☐ indifferently ☐ positively ☐ very positively

D8 **Is it important for you that your child knows English?**

☐ not at all ☐ a little ☐ quite important ☐ very important ☐ absolutely

D8.1 **Why?** *(Please state the most important reasons)*

____

____

____

PART E:
YOUR CHILD'S KNOWLEDGE & USE OF OTHER LANGUSGES

E1 **Does your child hear another language in the family?** ☐ Yes ☐ No

E1.1 **If so, which one(s)?** ____

E1.2 **Who speaks this language / these languages in the family?**
☐ me ☐ my partner ☐ both parents ☐ grandparents ☐ siblings

E2 **How well does your child know this language?**

My child can…	*not at all*	*a little*	*adequately*	*well*	*very well*
… understand when he/she hears others talking to each other	☐	☐	☐	☐	☐
… understand when he/she watches TV	☐	☐	☐	☐	☐
… speak	☐	☐	☐	☐	☐
… read	☐	☐	☐	☐	☐
… write	☐	☐	☐	☐	☐

E3 **Does the child attend courses in other languages besides Greek and English?**
☐ Yes ☐ No

E3.1 **If so, which one(s)?**
☐ German ☐ French ☐ Spanish ☐ Italian ☐ other: ___________

E3.2 **How many hours per week?** ____

E4 **Has the child lived in another country apart from Greece and the UK?**
☐ Yes ☐ No

E4.1 **If so, in which country and for how long?** ___________________________________

E4.2 **Did he/she attend school in this country?** ☐ Yes ☐ No

E4.3 **If so, for how long?** ____

PART F:
DIFFICULTIES WITH YOUR CHILD'S LANGUAGE DEVELOPMENT

F1 **Does your child have a hearing problem or has he/she ever had one?**

☐ Yes ☐ No

F2 **Does your child have problems with the languages that he/she speaks or has he/she ever had any (e.g. difficulties with the pronunciation of sounds or words)?**

☐ Yes ☐ No

F2.1 **If so, in which language?** ☐ English ☐ Greek ☐ both

F2.2 **Can you describe these problems?**

____

____

F3 **Does your child have any reading or writing problems or has he/she ever had any?**

☐ Yes ☐ No

F3.1 **If so, in which language?** ☐ English ☐ Greek ☐ both

F3.2 **Can you describe these problems?**

____

____

F4 **Is there anything that you would like to add or let us know about?**

____

____

PART G:
DEMOGRAPHIC INFORMATION

G1 **You are:** ☐ female ☐ male

G2 **Apart from you, how many adults in your family help to raise your child?** ________________

G3 **You are:** ☐ 25-35 years old ☐ 36-45 years old ☐ over 45 years old

G4 **Your partner is:** ☐ 25-35 years old ☐ 36-45 years old ☐ over 45 years old

G5 **Where did you grow up?**
☐ in the UK ☐ in Greece ☐ in both countries ☐ if elsewhere, where? __________

G6 **Where did your partner grow up?**
☐ in the UK ☐ in Greece ☐ in both countries ☐ if elsewhere, where? __________

G7 **How long have you been in the UK?**

☐ since birth ☐ 1-2 years ☐ 3-5 years ☐ 6-9 years ☐ over 10 years

G8 **Where were your parents born?**

☐ in the UK ☐ in Greece ☐ in both countries ☐ if elsewhere, where? __________

G9 **Where do your parents live?**

☐ in the UK ☐ in Greece ☐ in both countries ☐ if elsewhere, where? __________

G10 **How long has your partner been in the UK?**

☐ since birth ☐ 1-2 years ☐ 3-5 years ☐ 6-9 years ☐ over 10 years

G11 **Where were your partner's parents born?**

☐ in the UK ☐ in Greece ☐ in both countries ☐ if elsewhere, where? _______

G12 **Where do your partner's parents live?**

☐ in the UK ☐ in Greece ☐ in both countries ☐ if elsewhere, where? _______

G13 **In which country did you attend the following levels of education:**

	UK/USA	*Greece*	*other country*	*nowhere*
Primary Education	☐	☐	☐	☐
Compulsory Secondary Education	☐	☐	☐	☐
Upper Secondary Education	☐	☐	☐	☐
Professional training	☐	☐	☐	☐
Tertiary Education	☐	☐	☐	☐

G14 **In which country did your partner attend the following levels of education:**

	UK/USA	*Greece*	*other country*	*nowhere*
Primary Education	☐	☐	☐	☐
Compulsory Secondary Education	☐	☐	☐	☐
Upper Secondary Education	☐	☐	☐	☐
Professional training	☐	☐	☐	☐
Tertiary Education	☐	☐	☐	☐

G15 **What is your job?** ____

G16 **What is your partner's job?** ____

G17 **How long are you planning to stay in the UK? Choose the answer that suits you:**

☐ no more than one year

☐ 2 to 3 more years

☐ 4 to 5 more years

☐ as long as possible

☐ don't know yet

G18 **How many children do you have?** ____

G19 **How old are they?** ____

G20 **When was** ___________________________ **born?** _____________(Day/Month/Year)

G20.1 **Where was he/she born?**

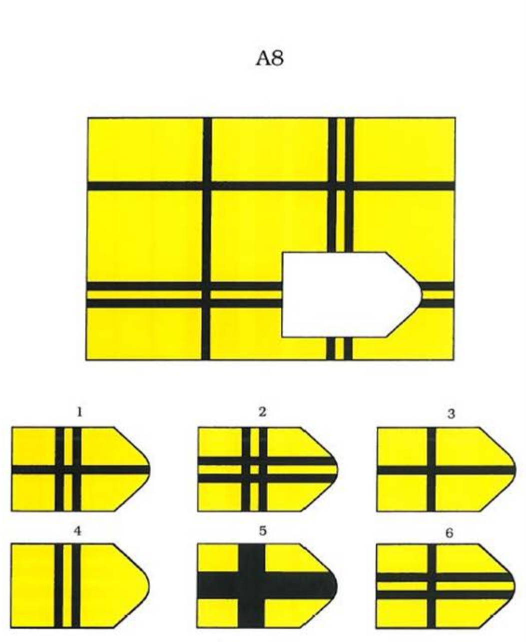
☐ in Greece ☐ in the UK ☐ if elsewhere, where? ___________

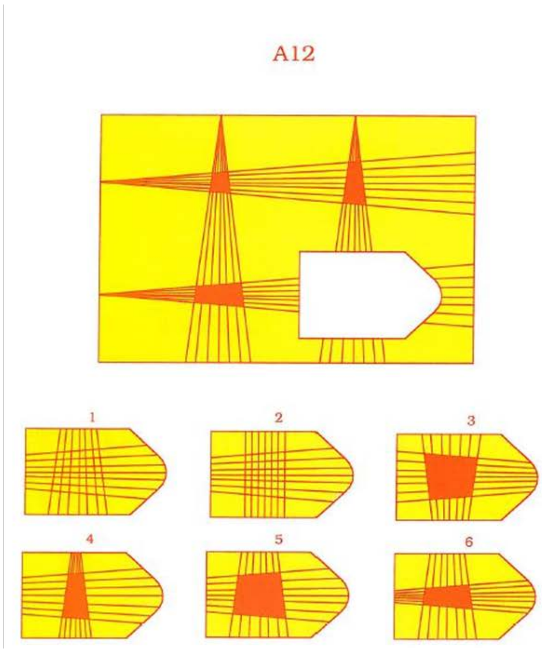
G.20.2 **If not born in the UK, how old was he/she when he/she came to this country?** ____

Thank you very much for your help and cooperation!

APPENDIX D

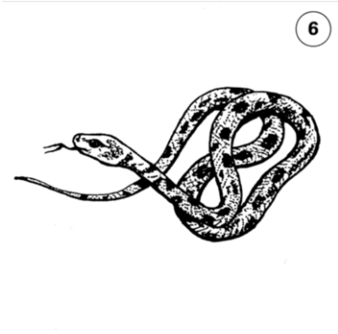
Two example items from the Coloured Progressive Matrices test (Raven & Court, 1998). The correct answer for item A8 on the left is 2 and the correct answer for item A12 on the right is 5.

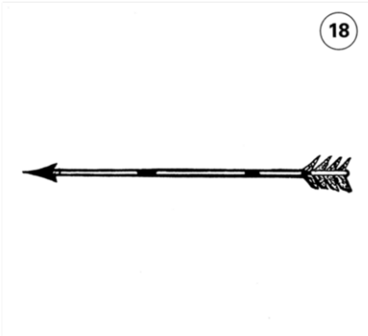


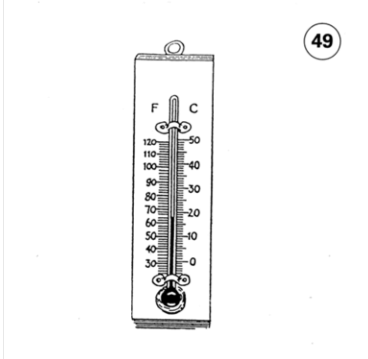


APPENDIX E

Three example items and full list of the 50 items of the Renfrew Word Finding Vocabulary Scale (Renfrew, 1995).







1. cup	26. necklace
2. key	27. jewels/jewellery
3. window	28. sleeve
4. moon	29. cuff
5. finger	30. violin
6. snake	31. bow
7. kite	32. binoculars
8. duck	33. pineapple
9. clown	34. lighthouse
10. crocodile/alligator	35. vegetables
11. helicopter	36. parachute
12. kangaroo	37. magnet
13. dice	38. anchor
14. snail	39. beehive
15. scarecrow	40. igloo
16. (coat) hanger	41. screw
17. owl	42. microphone
18. arrow	43. saddle
19. guitar	44. spanner
20. camel	45. aerial/antenna
21. watering can	46. racket
22. mermaid	47. sling
23. caterpillar	48. compass
24. map	49. thermometer
25. drill	50. steeple/spire

APPENDIX F

List of the 50 items of the Greek version of the Renfrew Word Finding Vocabulary Scale (Δοκιμασία Εκφραστικού Λεξιλογίου; Vogindroukas et al., 2009) and their English translations.

1. κλειδί	key	26. ρακέτα	racket
2. φίδι	snake	27. θερμόμετρο	thermometer
3. φεγγάρι	moon	28. φλιτζάνι	cup
4. κρεμάστρα	(coat) hanger	29. άγκυρα	anchor
5. παράθυρο	window	30. σέλα	saddle
6. κλόουν	clown	31. ανανάς	pineapple
7. χαρταετός/αετός	kite	32. τρυπάνι	drill
8. πάπια	duck	33. λαχανικά	vegetables
9. μπλούζα	pullover/jumper	34. βίδα	screw
10. μανίκι	sleeve	35. χάρτης	map
11. κιθάρα	guitar	36. βιολί	violin
12. ζάρια	dice	37. κεραία	aerial/antenna
13. σαλιγκάρι	snail	38. σκιάχτρο	scarecrow
14. ελικόπτερο	helicopter	39. κοσμήματα	jewels/jewellery
15. κουκουβλάγια	owl	40. μαγνήτης	magnet
16. γοργόνα	mermaid	41. γαλλικό κλειδί/κάβουρας	spanner
17. κροκόδειλος/ αλλιγάτορας	crocodile/alligator	42. κάμπια	caterpillar
18. δάχτυλο	finger	43. αλεξίπτωτο	parachute
19. καμήλα	camel	44. φάρος	lighthouse
20. κιάλια	binoculars	45. πυξίδα	compass
21. καγκουρό	kangaroo	46. ιγκλού	igloo
22. ποτιστήρι	watering can	47. κυψέλη	beehive
23. κολιέ	necklace	48. νάρθηκας/επίδεσμος	sling
24. βέλος	arrow	49. δοξάρι	bow
25. μικρόφωνο	microphone	50. τρούλος	dome

APPENDIX G

List of the 30 sentences and target structures of the English SRT (Marinis & Armon-Lotem, 2015).

1. They are eating the bananas in the park.	SVO + 1 auxiliary/modal
2. What did the princess buy last month?	object questions
3. The cow was kicked in the leg by the donkey.	long actional/non-actional passives
4. He will feed the cow before he waters the plants.	sentential adjuncts (adverbial)
5. The children enjoyed the sweets that they tasted.	object relatives (right branching)
6. The mum baked the meal that the children are eating.	object relatives (right branching)
7. Which picture did he paint at home yesterday?	object questions
8. The policeman has been looking at us.	SVO + 2 auxiliary/modal
9. The children were taken to the office.	short actional passive
10. The people will get a present if they clean the house.	sentential adjuncts (conditional)
11. The boy that the milkman helped has lost his way.	object relatives (centre embedded)
12. The kitten could have hit the ball down the stairs.	SVO + 2 auxiliary/modal
13. Which drink did the milkman spill in the house?	object questions
14. He was pushed hard against the ground.	short actional passive
15. She went to the nurse because was sick.	sentential adjuncts (adverbial)
16. He should wash the baby that the child is patting.	object relatives (right branching)
17. What did the father cook in the evening?	object questions
18. The boy must sweep the floor in the kitchen.	SVO + 1 auxiliary/modal
19. If the kids behave we will go into the garden.	sentential adjuncts (conditional)
20. She was stopped at the big red lights.	short actional passive
21. The mother was followed by the girl.	long actional/non-actional passives
22. They have been riding the goat around the garden.	SVO + 2 auxiliary/modal
23. Who have they seen near the steps?	object questions
24. The bee that the man swallowed had hurt him.	object relatives (centre embedded)
25. Who did the monkey splash near the water?	object questions
26. He wouldn’t have brought his friend if she was nasty.	sentential adjuncts (conditional)
27. She was seen by the doctor in the morning.	long actional/non-actional passives
28. The horse that the farmer pushed kicked him in the back.	object relatives (centre embedded)
29. She can bring the glass to the table.	SVO + 1 auxiliary/modal
30 The child ate breakfast after he washed his face.	sentential adjuncts (adverbial)

APPENDIX H

List of the 32 sentences and target structures of the Greek SRT (Marinis & Armon-Lotem, 2015) and their English translations.

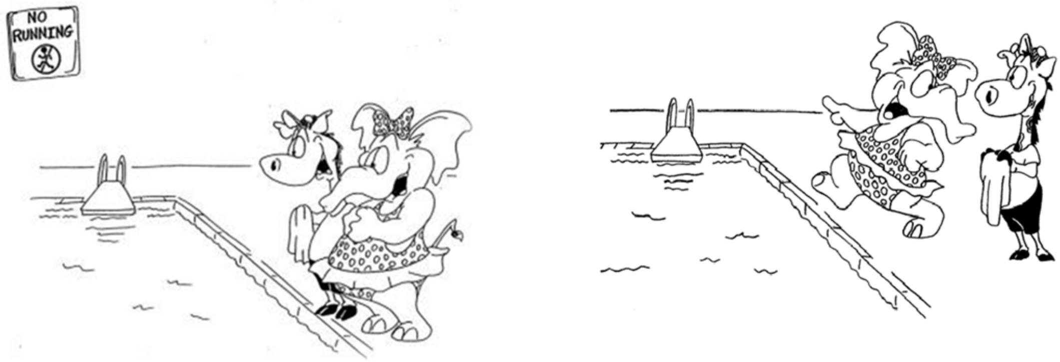
1. Η μητέρα έβαλε τις μπλούζες των κοριτσιών στο μπαλκόνι. “The mother put the girls’ blouses on the balcony.”	SVO
2. Ο ζωγράφος θέλει να μην πιάνουν οι φίλοι του τους πίνακές του. “The painter does not want his friends to touch his paintings.”	Negation
3. Τον καφέ τον ήπιε βιαστικά ο παππούς χθες στο καφενείο. “The grandfather drank his coffee in a hurry in the café yesterday.”	Clitic left dislocation
4. Ο χορευτής πήρε την ομπρέλλα του και περπάτησε στη δυνατή βροχή. “The dancer took his umbrella and walked in the heavy rain.”	Coordination
5. Ο παππάς έβλεπε πολλή ώρα τους τουρίστες που διάβαζαν τις πινακίδες. “The priest was watching for a long time the tourists who were reading the signs.”	Relative clause
6. Έκοψε το αγγούρι αφού καθάρισε καλά με νερό τις ντομάτες. “He/she cut the cucumber before he/she washed the tomatoes thoroughly with water.”	Adverbial clause
7. Η δασκάλα δεν είναι σίγουρη ποιο βιβλίο διάβασε η μαθήτρια. “The teacher is not sure which book the pupil read.”	Wh- complement clause
8. Ο αστυνόμος είδε την κοπέλα που του είχε πουλήσει ένα παγωτό. “The police officer saw the girl who had sold him an ice-cream.”	Relative clause
9. Ο τουρίστας ξέχασε τον οδηγό των διακοπών στο σπίτι. “The tourist forgot the travel guide at home.”	SVO
10. Ο προπονητής δεν ελπίζει να κερδίσει η ομάδα του σήμερα. “The coach hopes that his team won’t win today.”	Negation
11. Ο γεωργός τον φύτεψε τον κήπο του θείου μου με μικρές κερασιές. “The farmer planted my uncle’s garden with little cherry trees.”	Clitic doubling
12. Η μαγείρισσα σήκωσε το βιβλίο της και το έβαλε στο συρτάρι. “The cook picked up her book and put it in the drawer.”	Coordination
13. Η γιαγιά θυμόταν ότι σε αυτά τα μέρη πετούσαν περίεργα πουλιά. “The grandmother remembered that strange birds used to fly in these places.”	Complement clause
14. Ο δάσκαλος πήγε κινηματογράφο ενώ προτιμούσε να παίξει κιθάρα. “The teacher went to the cinema although he preferred to play guitar.”	Adverbial clause
15. Μόνο ο αστυνόμος γνώριζε τι έκλεψαν από το σαλόνι οι ληστές. “Only the police officer knew what the burglars stole from the living-room.”	Wh- complement clause
16. Οι εφημερίδες γράφουν πολλά για τον ληστή που έπιασε η αστυνομία. “The newspapers write a lot about the burglar who the police caught.”	Relative clause
17. Ο μανάβης πούλησε τις ώριμες φράουλες στην αγορά πολύ φθηνά. “The greengrocer sold the ripe strawberries cheaply at the market.”	SVO
18. Ο αθλητής ελπίζει ο αντίπαλός του να μην κερδίσει τον αγώνα. “The athlete hopes his opponent won’t win the competition.”	Negation
19. Την ταινία την είδε χτες ο δάσκαλος με τους μαθητές στο σινεμά. “The teacher watched the movie with his students at the cinema yesterday.”	Clitic left dislocation
20. Ο μαθητής αγόρασε μαρκαδόρους και ο φίλος του πήρε μολύβια. “The pupil bought markers and his friend got pencils.”	Coordination

21. Οι μαθήτριες έκλαιγαν που ο διευθυντής πούλησε τον πίνακά τους. “The students were crying because the headmaster sold their painting.”	Complement clause
22. Ο γείτονας αγόρασε το αυτοκίνητο πριν πουλήσει το μικρό σπίτι. “The neighbour bought the car before he sold the little house.”	Adverbial clause
23. Ο προπονητής ρώτησε τον αθλητή τι ύψος είχε ο πατέρας του. “The coach asked the athlete what his father’s height was.”	Wh- complement clause
24. Η καθαρίστρια κλώτσησε τη νοσοκόμα που βγήκε από το γραφείο. “The cleaning lady kicked the nurse who came out of the office.”	Relative clause
25. Οι οδηγοί άφησαν τους επιβάτες των λεωφορείων στην επόμενη στάση. “The drivers left the bus passengers at the next stop.”	SVO
26. Ο μάγειρας δεν πρότεινε να ψηθεί το ψάρι στο φούρνο. “The cook did not suggest that the fish be cooked in the oven.”	Negation
27. Το κορίτσι την έντυσε την κούκλα του με όμορφα φορέματα. “The girl dressed her puppet with beautiful dresses.”	Clitic doubling
28. Η μαμά μαγείρεψε μακαρόνια και η γιαγιά έφτιαξε μια πίτα. “The mother cooked spaghetti and the grandmother made a pie.”	Coordination
29. Οι νοσοκόμες είπαν ότι η πτήση του γιατρού έχει καθυστέρηση. “The nurses said that the doctor’s flight is delayed.”	Complement clause
30. Όταν το σχολείο έκλεισε το καλοκαίρι, τα παιδιά έτρεχαν στους δρόμους. “When the school closed for summer, the children were running in the streets.”	Adverbial clause
31. Η πεταλούδα ρώτησε τη μέλισσα τι θα φορούσε στη γιορτή. “The butterfly asked the bee what she would be wearing at the party.”	Wh- complement clause
32. Ο τζίτζικας διάβαζε ένα βιβλίο που έγραψε ο βασιλιάς της ζούγκλας. “The cicada was reading a book that the King of the Jungle wrote.”	Relative clause

APPENDIX I

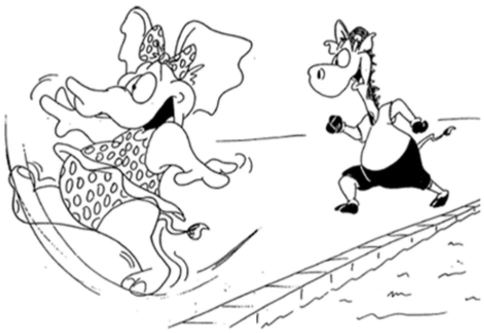
The four model stories used in the story re-tell task in English and Greek.

Story A2



One day a happy giraffe boy and a playful elephant girl went out to the nearby swimming-pool. Elephantina noticed a diving board from which they could dive as many times as they wanted. But neither of them saw the sign that said "NO RUNNING!"
Not wasting any time, Elephantina decided to start a competition by saying "Let's see who will be there first!"

Μια μέρα μία χαρούμενη καμηλοπάρδαλη αγοράκι , ο καμηλοπάρδαλης, και μία παιχνιδιάρα ελεφαντίνα πήγαν βόλτα στην πισίνα της γειτονιάς τους. Η ελεφαντίνα αμέσως πρόσεξε μία σανίδα από την οποία μπορούσαν να κάνουν πολλές βουτιές. Κανείς τους όμως δεν είδε τη ταμπέλα που έγραφε "μην τρέχετε".
Για να μη χάσουν χρόνο η ελεφαντίνα αποφάσισε να ξεκινήσει το παιχνίδι λέγοντας στον καμηλοπάρδαλη "Ας δούμε ποιος θα φτάσει πιο γρήγορα στη σανίδα! ".



They set off with Elephantina in front and Giraffo following her.
When Giraffo tried to reach her, Elephantina slipped and fell. Giraffo was frightened, when he noticed that she had hurt herself and burst into tears.

Ξεκίνησαν το τρέξιμο με την ελεφαντίνα μπροστά και τον καμηλοπάρδαλη να την ακολουθεί.
Όταν ο καμηλοπάρδαλης προσπαθούσε να τη φτάσει η ελεφαντίνα γλίστρησε και έπεσε. Ο φοβισμένος καμηλοπάρδαλης είδε ότι αυτή πονούσε και έκλαιγε.

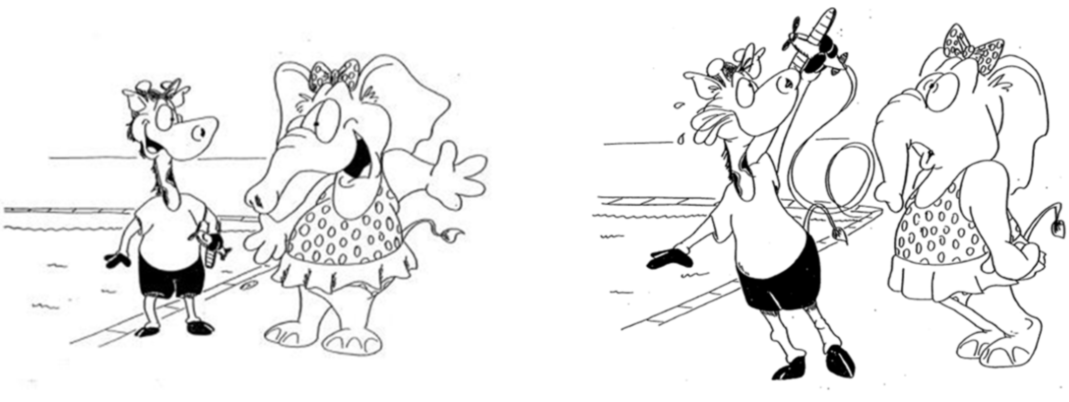
A lifeguard elephant noticed them and came up to them to see what their problem was.
With tears in her eyes, Elephantina explained to him what had happened. After having examined the wound, the lifeguard put a band-aid on it, while her concerned friend was watching.

Ένας ελέφαντας ναυαγοσώστης τους είδε και πλησίασε προς το μέρος τους για να δει ποιο ήταν το πρόβλημα.
Η ελεφαντίνα του εξήγησε κλαίγοντας τι συνέβη. Ο ναυαγοσώστης αφού εξέτασε την πληγή της της έβαλε ένα τσιρότο, καθώς ο ανήσυχος φίλος της παρακολουθούσε γονατιστός.

After that, they helped her to walk over to a bench to relax. Her friend, Giraffo, was relieved and glad that his friend looked better.
As soon as her friend had left, the lifeguard frowned at Elephantina and pointed to the sign that said "NO RUNNING!" and told her that she should be more careful next time. She promised to do so and thanked him for his help.

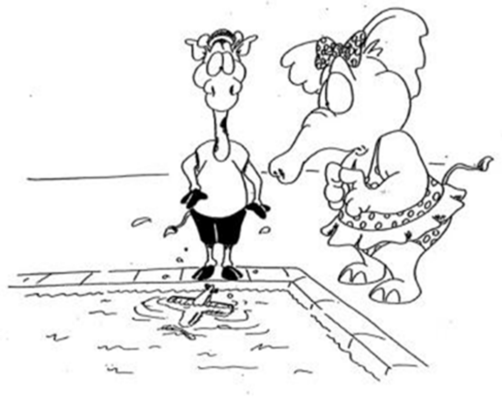
Αμέσως τη βοήθησαν να περπατήσει μέχρι το παγκάκι για να ξεκουραστεί. Ο φίλος της ο καμηλοπάρδαλης ανακουφίστηκε και χάρηκε που η φίλη του φαίνονταν καλύτερα.
Μόλις έφυγε ο φίλος της, ο ναυαγοσώστης κοίταξε την ελεφαντίνα αυστηρά και της έδειξε την πινακίδα που έγραφε "μην τρέχετε" και της είπε ότι την επόμενη φορά θα πρέπει να είναι πιο προσεχτική. Εκείνη του το υποσχέθηκε και τον ευχαρίστησε για τη βοήθεια του.

Story A3



One day, a playful giraffe boy and a cheerful elephant girl who were friends met at the nearby swimming pool. Elephantina saw that her friend was holding a small toy airplane.
As he was playing with it, his friend was watching him with admiration.

Μια μέρα μια παιχνιδιάρα καμηλοπάρδαλη αγοράκι, ο καμηλοπάρδαλης και μία χαρούμενη ελεφαντίνα, που είναι φίλοι συναντήθηκαν στην πισίνα κοντά στο σπίτι τους. Η ελεφαντίνα είδε ότι ο φίλος της κρατούσε στο χέρι του ένα αεροπλανάκι.
Έπαιζε με το αεροπλανάκι, καθώς η φίλη του τον κοίταζε εντυπωσιασμένη.

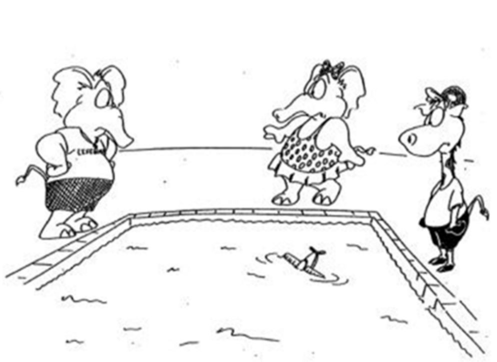


At some point, Elephantina became jealous, because she also wanted to play with the toy. So she decided to take it away from him. Her friend cried: "Oh no! Why did you take my toy? "
When Elephantina kept on playing with it, the plane accidentally fell into the water. Giraffo was sad, because he thought that the toy was ruined.

Η ελεφαντίνα κάποια στιγμή ζήλεψε γιατί ήθελε και αυτή να παίξει με αυτό. Αποφάσισε να του το αρπάξει αμέσως. Ο καμηλοπάρδαλης φώναξε: "Ωχ! οχι, γιατί μου πήρες το παιχνίδι μου; "
Ενώ η ελεφαντίνα συνέχιζε να παίζει, το αεροπλάνο της έπεσε κατά λάθος μέσα στο νερό. Ο καμηλοπάρδαλης στενοχωρήθηκε, γιατί σκέφτηκε ότι το παιχνίδι του χάλασε.

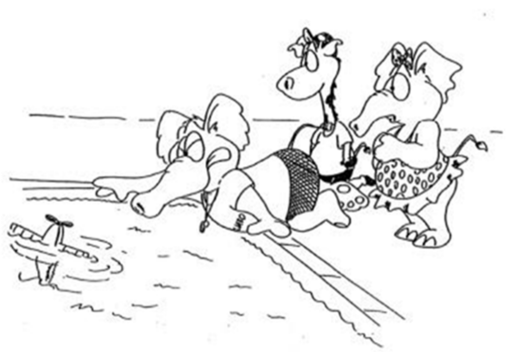
He became so angry that he started shouting at his friend, while she kept looking at him in fear.

Θύμωσε τόσο πολύ, που άρχισε να φωνάζει δυνατά στη φίλη του. Εκείνη τον κοιτούσε τρομαγμένη.



Suddenly, another elephant who had noticed what had happened appeared and wanted to help them. Elephantina went up to him.
She asked him if he had an idea of how to fetch the plane from the water, while Giraffo anxiously watched his toy sink.

Εκείνη την ώρα εμφανίστηκε ένας άλλος ελέφαντας, που πρόσεξε τι συνέβη και θέλησε να τους βοηθήσει. Αμέσως η ελεφαντίνα πλησίασε προς το μέρος του.
Την ίδια ώρα του ζήτησε να βρουν έναν τρόπο για να βγάλουν το αεροπλανάκι από το νερό, ενώ ο καμηλοπάρδαλης κοιτούσε με αγωνία, που το παιχνίδι του βυθίζονταν.

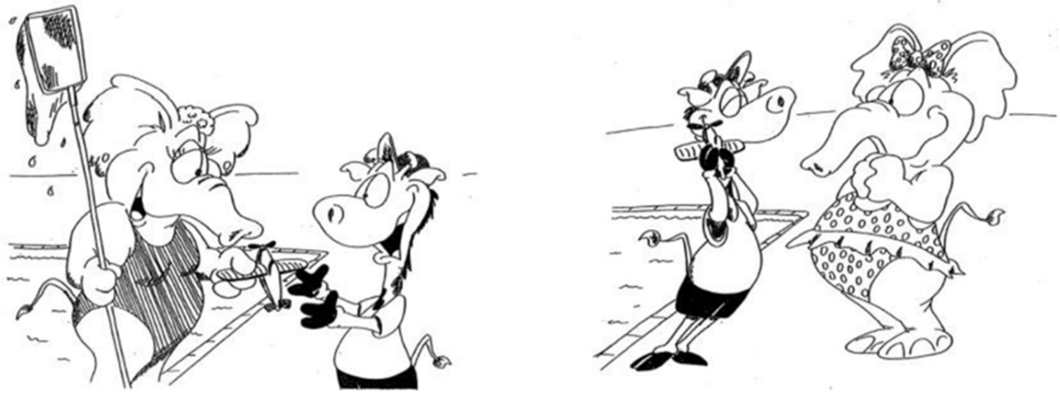


The two friends watched the elephant lean over as he was trying to pull the plane from the water, but in vain.
He explained that the plane was too far away and that he could not reach it. In the meantime, Giraffo had started to cry and Elephantina realised that she had made her friend unhappy.

Οι δύο φίλοι κοιτούσαν τον ελέφαντα που έσκυβε και προσπάθούσε να τραβήξει μάταια το αεροπλανάκι από το νερό.
Τους εξήγησε ότι το αεροπλανάκι είναι πολύ μακριά και δεν μπορεί να το φτάσει. Ο καμηλοπάρδαλης αμέσως έβαλε τα κλάματα, ενώ η ελεφαντίνα σκέφτονταν ότι έκανε τον φίλο της να στεναχωρηθεί.

Then, suddenly, a clever lady elephant who had been nearby came up to them. She had decided to help them and approached them with a net in her hand.
She started to fish the toy airplane from the water, while the others were watching with excitement.

Ξαφνικά μία έξυπνη κυρία ελεφαντίνα, που βρίσκονταν εκεί κοντά σκέφτηκε να τους βοηθήσει. Έτσι πλησίασε κρατώντας ένα δίχτυ στο χέρι.
Άρχισε να τραβάει το αεροπλανάκι, καθώς οι υπόλοιποι παρακολουθούσαν χαρούμενοι.



As soon as the lady elephant got hold of it, she gave it to Giraffo, who was very glad about this.
So, in the end, both friends were happy again. Giraffo had his toy back and Elephantina saw that her friend was happy again.

Μόλις η κυρία ελεφαντίνα το πήρε, το έδωσε στον καμηλοπάρδαλη, γεμίζοντάς τον με χαρά.
Οι δύο φίλοι ήταν πάλι χαρούμενοι. Ο καμηλοπάρδαλης είχε το παιχνίδι του πίσω και η ελεφαντίνα είδε τον φίλο της ξανά χαρούμενο.

Story B2


One day, a playful dog and a happy rabbit met in the forest. Since they had decided to have a picnic together, they had both brought a basket with food.
They were hungry and immediately sat down to eat. While Doggy was taking a sandwich from her basket she was surprised to see that her friend was unpacking many things from his basket and was beginning to eat greedily.

Μια μέρα μία παιχνιδιάρα σκυλίτσα και ένας χαρούμενος λαγός συναντήθηκαν στο δάσος. Επειδή είχαν αποφασίσει να κάνουν μαζί πικνίκ, είχαν φέρει και οι δύο από ένα καλαθάκι με φαγητό.
Καθώς ήταν πεινασμένοι κάθισαν να φάνε. Όταν η σκυλίτσα έβγαλε από το καλαθάκι της ένα σάντουιτς, παρατήρησε με έκπληξη τον φίλο της να βγάζει ένα σωρό πράγματα από το δικό του καλάθι και να τα καταβροχθίζει με λαιμαργία.


Astonished, she noticed that her friend devoured everything within no time.
It didn’t take very long before he started to complain: "Help, I feel sick and my stomach hurts! Do something".

Έκπληκτη, είδε, ότι ο φίλος της μέσα σε λίγα λεπτά είχε φάει όλα τα φαγητά του.
Δεν πέρασε πολύ ώρα και της λέει με παράπονο: "Βοήθεια! Ζαλίζομαι και πονάει το στομάχι μου, κάνε κάτι".


The dog wanted to help him and decided to run off to find someone who could help her friend. Luckily, she found a rabbit doctor on the road and was relieved.
While she was leading the doctor towards her sick friend who was still in agony, she explained the whole story. The doctor told her to calm down and promised her to help him.

Η σκυλίτσα ήθελε να τον βοηθήσει και αποφάσισε να τρέξει να βρει κάποιον για να βοηθήσει τον φίλο της. Για καλή της τύχη, βρήκε μια λαγουδίνα γιατρό στο δρόμο και χάρηκε.
Ενώ αυτή τραβούσε τη γιατρό προς τον ζαλισμένο φίλο της, που βρίσκονταν ακόμα σε αγωνία, της εξήγησε όλη την ιστορία. Η γιατρός της ζήτησε να ηρεμήσει και της υποσχέθηκε ότι θα τον βοηθήσει.


Without wasting time the doctor examined Bunny to see what the problem was.
Straight away, she realized that he had eaten too much and needed to walk a bit to feel better. While they were walking, he slowly started to feel better. The doctor advised him not to eat that much in the future.
Doggie was watching them walk and she was relieved that she had helped her friend. In the end, everybody was happy.

Μη χάνοντας χρόνο η γιατρός εξέτασε τον λαγό, για να δει τι είχε πάθει.
Γρήγορα κατάλαβε, ότι είχε παραφάει και χρειάζονταν περπάτημα για να ξεφουσκώσει. Καθώς προχωρούσαν ο λαγός ήταν ολοένα και καλύτερα. Η γιατρός τον συμβούλεψε να μην τρώει τόσο πολύ άλλη φορά. Η σκυλίτσα τους κοίταζε να περπατάνε και ήταν ανακουφισμένη, που βοήθησε τον φίλο της. Έτσι στο τέλος όλοι ήταν χαρούμενοι.

Story B3

One day a playful dog and a happy rabbit decided to take a walk in the woods. Bunny noticed that his friend pulled a cart with a beautiful balloon attached to it.
He decided to get the balloon so they could play with it. Doggie explained to him that they had to untie the balloon first.

Μια μέρα μία παιχνιδιάρα σκυλίτσα και ένας χαρούμενος λαγός, που είναι φίλοι σκέφτηκαν να πάνε μία βόλτα στο δάσος. Ο λαγός πρόσεξε ότι η φίλη του τραβούσε ένα καρότσι με ένα όμορφο μπαλόνι πάνω του.
Αμέσως αποφάσισε να πιάσει το μπαλόνι, για να παίξει με τη φίλη του. Η σκυλίτσα όμως του είπε ότι πρώτα θα έπρεπε να το λύσουν.

While his friend was waiting impatiently, Bunny began to untie it.
But accidentally, the balloon slipped through Bunny's fingers. Doggy was jumping up to grab it, shouting: "Oh no! My favourite balloon is flying away!"

Ο λαγός ξεκίνησε) να το λύνει, ενώ η φίλη του περίμενε ανυπόμονα να ξεκινήσουν το παιχνίδι.
Κατά λάθος όμως, το μπαλόνι έφυγε μέσα από τα χέρια του λαγού. Η σκυλίτσα πήδηξε ψηλά για να το φτάσει, φωνάζοντας: "Ωχ όχι! Το αγαπημένο μου μπαλόνι ανεβαίνει στον ουρανό!"

Doggy was so upset that she started to shout at her friend who looked at her, terrified.

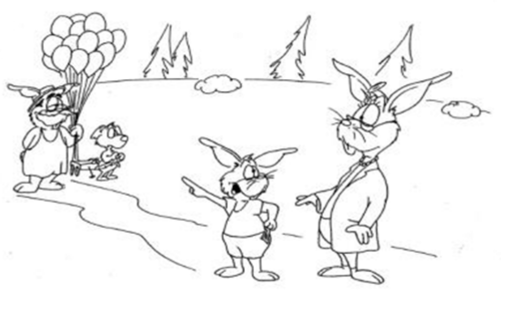
Η σκυλίτσα θύμωσε τόσο πολύ, που άρχισε να φωνάζει δυνατά στον φίλο της. Εκείνος την κοιτούσε τρομαγμένος.

Just then, the rabbit boy noticed an old rabbit who was holding a bunch of balloons. He thought that the only way to make his friend happy again was by getting her a new balloon.
As fast as he could, he ran up to the old rabbit and asked him for the most beautiful balloon he had so that he could give it to his sad friend.

Ξαφνικά ο λαγός παρατήρησε τον γερο-λαγό, που πουλούσε ένα σωρό μπαλόνια. Σκέφτηκε ότι ο μόνος τρόπος για να γίνει η φίλη του χαρούμενη είναι να της πάρει ένα καινούριο μπαλόνι.
Όσο πιο γρήγορα μπορούσε, έφτασε στο γερο-λαγό και του ζήτησε το πιο όμορφο μπαλόνι που είχε, για να το δώσει στη λυπημένη φίλη του.

The old rabbit wanted money for the balloon. So Bunny turned his pockets inside out, but found no money. He was sad, because he could not give it to his friend.
Doggy, who had been watching for some time and had seen what had happened, came over to them. The two friends approached him with a pitiable gaze. But even though they asked the old rabbit very politely, he wouldn’t give them the balloon.

Ο γερο-λαγός του ζήτησε λεφτά για το μπαλόνι. Έτσι, ο λαγός γύρισε τις τσέπες του ανάποδα, αλλά δεν βρήκε λεφτά. Στεναχωρήθηκε, γιατί δε θα μπορούσε να χαρίσει το μπαλόνι στη φίλη του. Η σκυλίτσα που παρατηρούσε από ώρα και έβλεπε τι συνέβαινε πλησίασε προς τα εκεί. Οι δυο φίλοι τον κοιτούσαν λυπημένοι αλλά ακόμα και όταν του το ζήτησαν ευγενικά, εκείνος δεν τους έδινε το μπαλόνι.

Luckily, the rabbit boy saw his mother passing by that very moment and hurried to catch her.
He explained what had happened and asked her to help them. His kind mother immediately agreed to do so.

Για καλή τους τύχη ο λαγός είδε τη μητέρα του να περπατάει στο δάσος και έτρεξε να την προλάβει.
Της εξήγησε τι συνέβη (subordination) και της ζήτησε να τους βοηθήσει. Η ευγενική μητέρα του δέχθηκε αμέσως.

She gave money to the old rabbit and bought two balloons instead of one, making both friends very happy.
Now each of them had their own balloon and they were ready to play.

Έδωσε λεφτά στον γερο-λαγό και πήρε δύο μπαλόνια αντί για ένα, κάνοντας τους δύο φίλους πολύ ευτυχισμένους.
Ο καθένας είχε το μπαλόνι του και όλοι ήταν έτοιμοι να ξεκινήσουν το παιχνίδι.

APPENDIX J

Full list of comprehension questions in English and Greek for each of the four stories.

Story A2

Picture	**Item**	**Question**	**Type**
1	1	Who is the story about? Για ποιον μιλάει η ιστορία;	factual
1	2	Where are the animals? Πού βρίσκονται τα ζωάκια;	factual
2	3	What did the elephant girl feel like here? Τι πιστεύεις πως αισθάνεται η ελεφαντίτσα εδώ;	mental state
3	4	What did the elephant girl do then? Και τι την βλέπουμε να κάνει;	factual
4	5	How did the friends feel here? Πώς νιώθουν εδώ οι δύο φίλοι;	mental state
4	6	Why (did they feel like that)? Γιατί (νιώθουν έτσι);	factual
5	7	What did the lifeguard think here? Τι πιστεύεις ότι σκέφτεται ο ναυαγοσώστης εδώ;	mental state
6	8	What did he do then (the lifeguard)? Και τι τον βλέπουμε να κάνει;	factual
7	9	How did the two friends feel then? Πώς αισθάνονται οι δύο φίλοι;	mental state
7	10	Why (did they feel like that)? Γιατί (αισθάνονται έτσι);	factual

Story A3

Picture	Item	Question	Type
1	1	Who is the story about? Για ποιον μιλάει η ιστορία;	factual
1	2	Where are the animals? Πού βρίσκονται τα ζωάκια;	factual
2	3	What did the elephant girl feel like here? Τι πιστεύεις πως αισθάνεται η ελεφαντίτσα εδώ;	mental state
3/4	4	What did the elephant girl do then? Και τι την βλέπουμε να κάνει;	factual
5	5	How did the friends feel here? Πώς νιώθουν εδώ οι δύο φίλοι;	mental state
5	6	Why (did they feel like that)? Γιατί (νιώθουν έτσι);	factual
6	7	What did the other elephant think here? Τι πιστεύεις ότι σκέφτεται ο άλλος ελεφαντάς εδώ;	mental state
8	8	What did he do then (the other elephant)? Και τι κάνει τελικά (ο άλλος ελέφαντας);	factual
9	9	How did the two friends feel here? Πώς αισθάνονται εδώ οι δύο φίλοι;	mental state
9	10	Why (did they feel like that)? Γιατί (αισθάνονται έτσι);	factual
10	11	What did the elephant lady think here? Τι πιστεύεις ότι σκέφτεται η κυρία ελεφαντίνα εδώ;	mental state
11	12	What did she do then (the elephant lady)? Και τι κάνει τελικά (η κυρία ελεφαντίνα);	factual
13	13	How did the two friends feel then? Πώς αισθάνονται οι δύο φίλοι εδώ;	mental state
13	14	Why (did the two friends feel like that)? Γιατί (αισθάνονται έτσι);	factual

Story B2

Picture	Item	Question	Type
1	1	Who is the story about? Για ποιον μιλάει η ιστορία;	factual
1	2	Where are the animals? Πού βρίσκονται τα ζωάκια;	factual
2	3	What did the rabbit feel like here? Τι πιστεύεις πώς αισθάνεται ο λαγός εδώ;	mental state
3	4	What did the rabbit do then? Και τι κάνει τελικά ο λαγός;	factual
4	5	How did the friends feel here? Πώς νιώθουν εδώ οι δύο φίλοι;	mental state
4	6	Why (did they feel like that)? Γιατί (νιώθουν έτσι);	factual
6	7	What did the doctor think here? Τι πιστεύεις ότι σκέφτεται η γιατρός εδώ;	mental state
7	8	What did she do then (the doctor)? Και τι κάνει τελικά (η γιατρός);	factual
8	9	How did the two friends feel then? Πώς αισθάνονται οι δύο φίλοι;	mental state
8	10	Why (did they feel like that)? Γιατί (αισθάνονται έτσι);	factual

Story B3

Picture	Item	Question	Type
1	1	Who is the story about? Για ποιον μιλάει η ιστορία;	factual
1	2	Where are the animals? Πού βρίσκονται τα ζωάκια;	factual
2	3	What did the rabbit feel like here? Τι πιστεύεις πως αισθάνεται ο λαγός εδώ;	mental state
3	4	What did the rabbit do then? Και τι κάνει τελικά ο λαγός;	factual
5	5	How did the friends feel here? Πώς νιώθουν εδώ οι δύο φίλοι;	mental state
5	6	Why (did they feel like that)? Γιατί (νιώθουν έτσι);	factual
6	7	What did the rabbit boy think here? Τι πιστεύεις ότι σκέφτεται το αγόρι-λαγός εδώ;	mental state
7	8	What did he do then (the rabbit boy)? Και τι κάνει τελικά (το αγόρι-λαγός);	factual
9	9	How did the two friends feel then? Πώς αισθάνονται οι δύο φίλοι εδώ;	mental state
9	10	Why (did they feel like that)? Γιατί (αισθάνονται έτσι);	factual
11	11	What did the rabbit mother think here? Τι πιστεύεις ότι σκέφτεται η μαμά του λαγού εδώ;	mental state
12	12	What did she do then (the rabbit mother)? Και τι κάνει τελικά (η μαμά του λαγού);	factual
13	13	How did the two friends feel like then? Πώς αισθάνονται οι δύο φίλοι εδώ;	mental state
13	14	Why (did they feel like that)? Γιατί (αισθάνονται έτσι);	factual

APPENDIX K

List of trials for the digit backwards task.

Practice	List	Answer	Score (1 or 0)	Span	List	Answer	Score (1 or 0)
P1	2 3			**5**	2 1 4 9 8		
P2	5 4			**5**	5 7 1 4 2		
P3	3 4 5			**5**	2 7 4 6 3		
P4	5 2 4			**5**	9 5 1 4 2		
				5	3 5 8 2 6		
				5	4 6 3 1 5		
Span							
2	2 7			**6**	5 2 1 7 9 3		
2	5 9			**6**	2 7 6 3 8 5		
2	3 1			**6**	4 8 3 5 2 7		
2	9 7			**6**	8 5 2 9 1 3		
2	4 6			**6**	1 9 5 8 2 4		
2	8 4			**6**	6 1 3 9 5 2		
3	8 1 4			**7**	8 3 5 2 9 4 1		
3	6 3 7			**7**	6 3 1 9 4 7 5		
3	4 6 2			**7**	5 8 7 2 4 9 3		
3	2 5 9			**7**	7 9 2 6 1 9 3		
3	7 3 5			**7**	8 5 2 4 9 3 6		
3	9 4 3			**7**	9 6 2 8 1 4 7		
				7	8 3 5 2 9 4 1		
4	2 7 1 4						
4	5 2 7 3						
4	6 3 8 4			**Total number of correct answers: _____**			
4	1 5 4 9						
4	9 6 5 8						
4	8 1 6 2						

APPENDIX L

First card of the RAN with digits.

4	7	8	5	2	3	7	4	3
8	2	5	3	5	7	2	8	4
7	5	3	4	8	2	7	3	8
5	2	4	8	3	5	4	7	2

APPENDIX M

List of real word and pseudoword items for the English Lexical Decision Task.

	Item	Status	Length (letters)	Length (syllables)	Frequency
1	face	word	4	1	high
2	king	word	4	1	high
3	wood	word	4	1	high
4	fish	word	4	1	high
5	train	word	5	1	high
6	plant	word	5	1	high
7	night	word	5	1	high
8	river	word	5	2	high
9	garden	word	6	2	high
10	flower	word	6	2	high
11	police	word	6	2	high
12	rabbit	word	6	2	high
13	monster	word	7	2	high
14	kitchen	word	7	2	high
15	picture	word	7	2	high
16	cage	word	4	1	mid
17	bone	word	4	1	mid
18	soup	word	4	1	mid
19	gift	word	4	1	mid
20	snail	word	5	1	mid
21	truck	word	5	1	mid
22	plate	word	5	1	mid
23	power	word	5	2	mid
24	pepper	word	6	2	mid
25	tunnel	word	6	2	mid
26	battle	word	6	2	mid
27	shadow	word	6	2	mid
28	country	word	7	2	mid
29	journey	word	7	2	mid
30	soldier	word	7	2	mid
31	twig	word	4	1	low
32	scar	word	4	1	low
33	wing	word	4	1	low
34	skill	word	4	1	low
35	wrist	word	5	1	low
36	grape	word	5	1	low
37	flame	word	5	1	low
38	anger	word	5	2	low
39	almond	word	6	2	low
40	needle	word	6	2	low
41	pastry	word	6	2	low
42	target	word	6	2	low
43	address	word	7	2	low
44	baggage	word	7	2	low
45	spinach	word	7	2	low

	Item	Status	Length (letters)	Length (syllables)	Orthographic neighbours (N)
46	hars	pseudo	4	1	30
47	cale	pseudo	4	1	27
48	sare	pseudo	4	1	33
49	pake	pseudo	4	1	24
50	slank	pseudo	5	1	15
51	betch	pseudo	5	1	13
52	shate	pseudo	5	1	14
53	bolly	pseudo	5	2	16
54	barger	pseudo	6	2	11
55	sutter	pseudo	6	2	13
56	canger	pseudo	6	2	14
57	tocket	pseudo	6	2	7
58	gooting	pseudo	7	2	10
59	cailing	pseudo	7	2	15
60	sharter	pseudo	7	2	7
61	nisc	pseudo	4	1	1
62	lalb	pseudo	4	1	1
63	symn	pseudo	4	1	1
64	doid	pseudo	4	1	2
65	buice	pseudo	5	1	1
66	choil	pseudo	5	1	2
67	fluth	pseudo	5	1	2
68	wigon	pseudo	5	2	1
69	tissug	pseudo	6	2	1
70	radsin	pseudo	6	2	1
71	mencil	pseudo	6	2	1
72	virtim	pseudo	6	2	1
73	stissor	pseudo	7	2	1
74	bisbuit	pseudo	7	2	1
75	stopach	pseudo	7	2	1
76	smey	pseudo	4	1	0
77	pirf	pseudo	4	1	0
78	kunx	pseudo	4	1	0
79	twup	pseudo	4	1	0
80	splum	pseudo	5	1	0
81	phrap	pseudo	5	1	0
82	vaurd	pseudo	5	1	0
83	bryet	pseudo	5	2	0
84	clowzy	pseudo	6	2	0
85	roifar	pseudo	6	2	0
86	peflin	pseudo	6	2	0
87	ettcup	pseudo	6	2	0
88	acclict	pseudo	7	2	0
89	congelb	pseudo	7	2	0
90	snophet	pseudo	7	2	0

APPENDIX N

List of real word, pseudoword and non-word items for the Greek Lexical Decision Task.

	Item	Status	Gender	Length (syllables)	Frequency
1	ελιά	word	fem	2	high
2	στοά	word	fem	2	high
3	φλέβα	word	fem	2	high
4	σκάλα	word	fem	2	high
5	ξενιτιά	word	fem	3	high
6	πυρκαγιά	word	fem	3	high
7	βελόνα	word	fem	3	high
8	αρκούδα	word	fem	3	high
9	τράπεζα	word	fem	3	high
10	μέλισσα	word	fem	3	high
11	ψαράς	word	masc	2	high
12	φρουρός	word	masc	2	high
13	λύκος	word	masc	2	high
14	τόνος	word	masc	2	high
15	κυνηγός	word	masc	3	high
16	θαυμασμός	word	masc	3	high
17	καθρέπτης	word	masc	3	high
18	καυστήρας	word	masc	3	high
19	φοίνικας	word	masc	3	high
20	πρίγκιπας	word	masc	3	high
21	φωλιά	word	fem	2	mid
22	ποδιά	word	fem	2	mid
23	πάπια	word	fem	2	mid
24	μπάλα	word	fem	2	mid
25	ζωγραφιά	word	fem	3	mid
26	αγκαλιά	word	fem	3	mid
27	μπανάνα	word	fem	3	mid
28	σταγόνα	word	fem	3	mid
29	άγκυρα	word	fem	3	mid
30	άγνοια	word	fem	3	mid
31	βυθός	word	masc	2	mid
32	πηλός	word	masc	2	mid
33	κόπος	word	masc	2	mid
34	δύτης	word	masc	2	mid
35	αδερφός	word	masc	3	mid
36	πυρετός	word	masc	3	mid
37	αέρας	word	masc	3	mid
38	τυφώνας	word	masc	3	mid
39	καύσωνας	word	masc	3	mid
40	όροφος	word	masc	3	mid
41	γροθιά	word	fem	2	low
42	σουπιά	word	fem	2	low
43	μύγα	word	fem	2	low
44	κόλλα	word	fem	2	low
45	μυρωδιά	word	fem	3	low
46	παγωνιά	word	fem	3	low
47	ευθεία	word	fem	3	low
48	πατάτα	word	fem	3	low
49	φράουλα	word	fem	3	low
50	άμαξα	word	fem	3	low

51	χυμός	word	masc	2	low
52	τροχός	word	masc	2	low
53	δίσκος	word	masc	2	low
54	βήχας	word	masc	2	low
55	πετεινός	word	masc	3	low
56	σκελετός	word	masc	3	low
57	νιπτήρας	word	masc	3	low
58	γορίλας	word	masc	3	low
59	φάκελος	word	masc	3	low
60	σκίουρος	word	masc	3	low
61	ζλωμά	illegal	fem	2	
62	χβηρά	Illegal	fem	2	
63	γτένα	illegal	fem	2	
64	κδίτα	Illegal	fem	2	
65	μλορομά	illegal	fem	3	
66	σδερατά	Illegal	fem	3	
67	λροφένα	illegal	fem	3	
68	ζριπέτα	Illegal	fem	3	
69	κχάλιμα	illegal	fem	3	
70	βτέτιμα	Illegal	fem	3	
71	λκορός	illegal	masc	2	
72	νκομός	Illegal	masc	2	
73	πφίκος	illegal	masc	2	
74	κγήμας	Illegal	masc	2	
75	ρτικορός	illegal	masc	3	
76	κμαλετάς	Illegal	masc	3	
77	ρνιτήρας	illegal	masc	3	
78	τγοτίμας	Illegal	masc	3	
79	ζκάμενος	illegal	masc	3	
80	ζπόνανας	Illegal	masc	3	
81	στηλιά	pseudo	fem	2	high
82	φτοά	pseudo	fem	2	high
83	σταίρα	pseudo	fem	2	high
84	πράτα	pseudo	fem	2	high
85	στανταλιά	pseudo	fem	3	high
86	φτυγανιά	pseudo	fem	3	high
87	προμπέτα	pseudo	fem	3	high
88	τριμπίδα	pseudo	fem	3	high
89	κτίμακα	pseudo	fem	3	high
90	κρίαινα	pseudo	fem	3	high
91	πτυλός	pseudo	masc	2	high
92	πλοιός	pseudo	masc	2	high
93	σκόχος	pseudo	masc	2	high
94	τρόνος	pseudo	masc	2	high
95	χτιστιανός	pseudo	masc	3	high
96	κλητικός	pseudo	masc	3	high
97	κραστήρας	pseudo	masc	3	high
98	κροδότης	pseudo	masc	3	high
99	τράκουλας	pseudo	masc	3	high
100	πλάκτορας	pseudo	masc	3	high

101	κλευρά	pseudo	fem	2	mid
102	σπιά	pseudo	fem	2	mid
103	φρόγα	pseudo	fem	2	mid
104	κρέζα	pseudo	fem	2	mid
105	σφαλωσιά	pseudo	fem	3	mid
106	σφιουνιά	pseudo	fem	3	mid
107	κλατεία	pseudo	fem	3	mid
108	κλωρίδα	pseudo	fem	3	mid
109	βράτεζα	pseudo	fem	3	mid
110	τράουλα	pseudo	fem	3	mid
111	φρασμός	pseudo	masc	2	mid
112	πριγμός	pseudo	masc	2	mid
113	σκούρνος	pseudo	masc	2	mid
114	βλάδος	pseudo	masc	2	mid
115	σφελετός	pseudo	masc	3	mid
116	βρεσβευτής	pseudo	masc	3	mid
117	δροφέας	pseudo	masc	3	mid
118	φταθμάρχης	pseudo	masc	3	mid
119	πλόσκοπος	pseudo	masc	3	mid
120	φτέφανος	pseudo	masc	3	mid
121	δραδιά	pseudo	fem	2	low
122	προσιά	pseudo	fem	2	low
123	δρέμα	pseudo	fem	2	low
124	σπούπα	pseudo	fem	2	low
125	κνειδαριά	pseudo	fem	3	low
126	γροθορά	pseudo	fem	3	low
127	φλουτιέρα	pseudo	fem	3	low
128	φλοντίδα	pseudo	fem	3	low
129	στρόνοια	pseudo	fem	3	low
130	γλίμακα	pseudo	fem	3	low
131	γραγμός	pseudo	masc	2	low
132	χλοιός	pseudo	masc	2	low
133	χλώνος	pseudo	masc	2	low
134	μπροίσος	pseudo	masc	2	low
135	σβοχασμός	pseudo	masc	3	low
136	φλεβασμός	pseudo	masc	3	low
137	θρομέας	pseudo	masc	3	low
138	σκασίκλας	pseudo	masc	3	low
139	σπόπελος	pseudo	masc	3	low
140	σβίουρος	pseudo	masc	3	low

APPENDIX O

List of items of the Single Word Reading Test (Foster, 2007).

1	see	31	medicine
2	look	32	strengthen
3	play	33	source
4	was	34	creative
5	like	35	material
6	this	36	eventually
7	next	37	hygiene
8	house	38	despite
9	going	39	calm
10	bell	40	journalism
11	hang	41	excitable
12	stand	42	dehydration
13	their	43	persuade
14	living	44	aggrieved
15	again	45	originate
16	first	46	courageous
17	slowly	47	atmospheric
18	score	48	familiarize
19	found	49	scenic
20	bread	50	recurrence
21	scream	51	ferocious
22	journey	52	cynical
23	suppose	53	excursion
24	yawned	54	coincidental
25	should	55	abysmal
26	tissue	56	endeavour
27	caught	57	rheumatism
28	stretching	58	haemorrhage
29	tongue	59	liaise
30	copies	60	pseudonym

APPENDIX P

Pseudowords from Task 1 of the TEST-A (Panteliadou & Antoniou, 2007).

1	τεπό	13	πλωχθρασματικών
2	τραίπα	14	γελιζανερής
3	ατζέλο	15	ποσσεινάθωκης
4	λαστρέμη	16	λάμπρενο
5	χρεσσιδούλα	17	ειγγασελάορα
6	κλωστραμπούκι	18	αγκρηνός
7	αμπρογέλι	19	ζεράκολυ
8	βηφελίδα	20	γδέκλωνο
9	δαταβά	21	στρουφάλομπρι
10	ηκοισελακώτων	22	σκαυψημπρά
11	φομπλέμο	23	μπακτευδίκρουνας
12	ψωριζακό	24	τευλαιντευώς

Real words from Task 2 of the TEST-A (Panteliadou & Antoniou, 2007).

1	άλλος	28	πανεμπιστημιακών
2	ρύζι	29	ρακοσυλλέκτης
3	θάλασσα	30	καλλιτεχνήματα
4	σπαθί	31	ξιφομαχώ
5	γυμνός	32	ξεκαρδιστήκαμε
6	χαϊδεύω	33	εφαρμοστός
7	λεωφορείο	34	εκπαιδευμένος
8	κουρδίζω	35	μαγνητοσκόπηση
9	οικογένεια	36	ίλιγγος
10	τζάμια	37	συγκαλύπτεις
11	ωραίος	38	ενσωμάτωση
12	ύμνος	39	φαλαινοθηρικό
13	βραδιάζει	40	διαστρωμάτωση
14	οινόπνευμα	41	χηνοβοσκός
15	παρακείμενος	42	σαγματοπωλείο
16	πλαστικοποιημένος	43	δακτυλοδεικτούμενος
17	γελοιογραφία	44	παγοπώλισσα
18	συμμορφώθηκα	45	εγχειρίδιο
19	κόσμημα	46	τερεβινθέλαιο
20	καταγγέλλω	47	βδελυγμός
21	παγκοσμιότητα	48	εκσφενδονίζω
22	βαθυμετρικός	49	αρθρίτιδα
23	γαλακτοποίηση	50	ταπεινοφροσύνη
24	τσιγγάνος	51	εγγειοβελτιωτικός
25	αβάπτιστος	52	ρευστοποιήσιμος
26	συνδέονται	53	υαλογραφώ
27	υπερπαραγωγή		

APPENDIX Q

Results for the cross-language comparisons of the bilingual children's performances.

Measure	n	English (*M, SD*)	Greek (*M, SD*)	*t*	*p*	*d*
LF	50	29.1 (7.8)	19.3 (6.9)	8.76	<.001	1.24
SRT-accuracy (%)	48	89.3 (8.0)	61.5 (27.6)	6.54	<.001	0.95
RC-composite (%)	44	76.0 (9.8)	47.7 (32.9)	5.44	<.001	0.82
LDT-accuracy (%)	47	89.9 (7.7)	80.6 (10.5)	5.39	<.001	0.78
LDT- *A'*	47	94.0 (5.0)	86.7 (8.9)	5.12	<.001	0.76
SRT-grammaticality (%)	48	95.1 (7.3)	81.3 (17.4)	4.74	<.001	0.69
LDT-lexicality (ms)	47	495 (442)	1131 (947)	-4.59	<.001	0.67
SRT-structure (%)	48	95.7 (5.9)	79.2 (24.4)	4.32	<.001	0.63
vocabulary (max. 50)	50	38.1 (6.5)	30.4 (10.2)	3.98	<.001	0.56
RAN (seconds)	50	30.8 (7.8)	41.1 (20.9)	-3.65	<.001	0.52
RC-passage (%)	32	75.3 (9.9)	61.0 (28.2)	2.79	.009	0.49
story-grammaticality	50	4.5 (7.6)	13.8 (20.4)	-2.85	.006	0.40
story-verb diversity	50	55.2 (6.9)	51.9 (8.1)	2.66	.010	0.38
CQ-factual (%)	50	94.7 (6.7)	90.3 (11.1)	2.40	.021	0.34
decoding (%)	50	80.9 (13.2)	73.7 (26.5)	2.34	.024	0.33
CQ-mental (%)	50	89.3 (8.2)	85.1 (12.5)	2.17	.035	0.30
verbal WM (max. 36)	50	18.0 (4.8)	17.4 (4.4)	1.41	.164	0.19
story-length	50	53.8 (14.1)	52.6 (15.3)	0.63	.530	0.09
story-complexity	50	34.5 (9.2)	34.7 (9.0)	-0.11	.912	0.02

Note. The means for story complexity, verb diversity, and story grammaticality represent the original scores (i.e., ratios) multiplied by 100.

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