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Disentangling the effect of bilingualism in attention from socioeconomic influences: A lifespan approach

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Disentangling the effect of bilingualism in attention from socioeconomic influences: A lifespan approach

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Abstract

There is growing evidence that brain structure and cognitive performance can be moulded from various forms of experience. Bilingualism seems to form such an experience, with studies mainly showing a bilingual advantage over monolinguals in executive control of attention. This has been attributed to bilinguals' lifelong practice in controlling two simultaneously active languages while using only one during communication. However, the problematic replicability of some of the main findings of relevant studies suggests that a confounding factor may have influenced their results. We suggest this could be the socioeconomic status (SES) of the participants, which has been inadequately controlled for in the majority of those studies, despite evidence on SES's strong influences on the cognitive system. Also, research has largely neglected the possible effects of bilingualism in the other two main attention functions, alerting and orienting. Four experiments were designed to explore the bilingual effect in executive attention, alerting and orienting, in children, young and old adults, bilingual in Albanian and Greek or monolingual in Greek, all of low SES. Several cognitive tasks were used to detect the bilingual effect. An additional innovation of this investigation was the language-switching task we used as an index of bilingual proficiency, to compensate for the questionable reliability of self-report measures that have been used up to date for this purpose. This also enabled us to determine what level of bilingual experience is required to influence cognition and to explore possible commonalities between the mechanisms underlying bilingual language-switching and executive attentional control. Our results suggest that, when controlling for SES and when bilinguals are balanced, there is a bilingual effect in executive attention and alerting. However it is weaker than what has been suggested, as specific

manipulations were required to detect it (i.e. individuals with age-related cognitive decline, under high working memory load).

Publications, Posters and Presentations

Publications

Ladas, A. I., Vivas, A. B., Frantzidis, C., & Bamidis, P.(2011). Spontaneous blink rate as a biological marker of dopamine function in old adults with mild cognitive impairment. *Neuroscience Letters, 500, Supplement 1,* e45

Frantzidis, C., Semertzidou, A., Ladas, A. I., Karagianni, M., Lithari, C., Kyrillidou, A., Grigoriadou, E., Klados, M. A., Vivas, A. B., Kounti, F., Tsolaki, M., Pappas, C., & Bamidis, P. (2011). Detecting neurophysiological alterations during Mild Cognitive Impairment and Dementia using wavelet-based energy computation and a Mahalanobis Distance classifier. *Neuroscience Letters, 500, Supplement 1,* e53

Bamidis, P., Frantzidis, C., Kyrillidou, A., Ladas, A. I., Grigoriadou, E., Billis, A., Konstantinidis, E., Zilidou, V., Mouzakidis, C., Semertzidou, A., Karagianni, M., Vivas, A. B., Tsolaki, M. (2011). Cognitive training, physical exercise and information technology: Neuroscientific challenges and first evidence from the LLM project *Neuroscience Letters, 500, Supplement 1,* e6

Presentations

Oral presentation & Best Paper Award: Frantzidis, C. A., Ladas, A. I., Diamantoudi, M. D., Semertzidou, A., Grigoriadou, E., Tsolaki, A. et al. "*What* are the symbols of Alzheimer? A Permutation Entropy based symbolic analysis for the detection of early changes of the electroencephalographic complexity due to mild Alzheimer", at the IEEE 12th International Conference on BioInformatics and BioEngineering, Larnaca, Cyprus, 11th -13th November, 2012

Oral presentation: Ladas, A. I., Zilidou, V., Romanopoulou, E., & Frantzidis, C. A. "The effects of physical training in the cognition and neurophysiology of the elderly: Encouraging results from the Long Lasting Memories project", at the 1st Conference for Physical Exercise and Physiotherapy of the Elderly, Thessaloniki, Greece, 14th – 16th December, 2012

Oral presentation: Ladas, A. I. & Grigoriadou, E. "Neuropsychological assessment of the effects of physical and cognitive training in the elderly participating in the Long Lasting Memories project", at the 1st Conference of Neuropsychology for the Elderly, Thessaloniki, Greece, 18th – 20th October, 2012.

Oral presentation: Ladas, A. I., Vivas, A. B. & Siegal, M. "Is attention influenced by bilingualism in young children of low socioeconomic status?", at the 7th SEERC Doctoral Conference, Thessaloniki, Greece, 24th – 25th September, 2012.

Oral presentation: Ladas, A. I., Vivas, A. B. & Siegal, M. "Attentional mechanisms in bilingualism.", at the Sheffield Doctoral Conference, Psychology department, Sheffield, UK, 16th – 19th May, 2011.

Oral Presentation: Ladas, A. I., Vivas, A. B., Frantzidis, C. & Bamidis, P. D. "Early prediction of transition from Mild Cognitive Impairment to dementia: Proposal of a new index of central nervous function", at the 7th National Interdisciplinary Conference on Alzheimer Disease & Related Disorders, Thessaloniki, Greece, 15th – 20th February, 2011.

Oral presentation: Ladas, A. I., Vivas, A. B. & Siegal, M. "Attentional processes of children and adults bilingual in Albanian and Greek." 6th SEERC Doctoral Conference, Thessaloniki, Greece, 19th – 20th September, 2011.

Oral presentation: Billis, A. S., Konstantinidis, E. I., Ladas, A. I., Tsolaki, M. N., Pappas, C. & Bamidis, P.D. “Evaluating affective usability experiences of an exergaming platform for seniors.” at the 10th International Workshop on Biomedical Engineering, 5th – 7th October, 2011.

Posters

Poster presentation: Frantzidis, C., Ladas, A. I., Karagianni, M., Semertzidou, A., Klados, M. A., Tsolaki, M., Pappas, C., & Bamidis, P. D. “Using synchronization techniques based on wavelet entropy for the early diagnosis of Alzheimer's with electroencephalogram.” , at the 4th Panhellenic Conference on Biomedical Engineering, Athens, Greece, 20th – 21st January, 2012.

Poster presentation: Semertzidou, A., Frantzidis, C., Ladas, A. I., Karagianni, M., Tsolaki, M., Hatjileondiadis, L. & Bamidis, P. D. “Detection of emotional content in the elderly using neurophysiological recordings”, at the 4th Panhellenic Conference on Biomedical Engineering, Athens, Greece, 20th – 21st January, 2012.

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Introduction – The effect of bilingualism on attention processes

Without language, we would not be able to communicate our emotions, ideas and thoughts to our conspecifics. The peculiarity of language is highlighted by the fact that it is a uniquely human faculty (Reber & Reber, 2001), as also stated by the very word used to characterize a human being in the Greek language (i.e. “anthropos”), which means “the one who utters speech”. It is thus unsurprising that language has long been the focus of scientific endeavour, cognitive scientists being no exception.

1.1 The phenomenon of bilingualism and cognition

A language phenomenon of great interest to cognitive researchers is bilingualism. Given the complex nature of bilingualism, the categorization of a bilingual individual depends on the definition of bilingualism a researcher uses (Gottardo & Grant, 2008). The majority of research who has studied bilingualism and cognition use a pragmatic definition of bilingualism: It is the ability of a person to be fluent in two languages (Harley, 1995; Martin, 2006). The level of proficiency in the two languages is central to this definition and is directly influenced by the degree to which one uses the two languages in her everyday life, frequently termed as “language use” (e.g. Brown, Bown & Eggett, 2009; Costa, Hernandez & Sebastian-Galles, 2008; Garrat & Kelly, 2008). Thus, according to this level-of-proficiency definition, a bilingual individual can be classified as a *dominant bilingual* (i.e. being more proficient in one of the two languages) or a *balanced bilingual* (i.e. equally proficient in both languages) (Gottardo & Grant, 2008; Reber & Reber, 2001).

A historical overview of the cognitive effects of bilingualism shows that it has been the focus of research ever since the late 30’s (Leopold, 1939, cited in Kolers & Paradis, 1980). More recently it has also acquired a socio-political dimension. That is, due to fundamental changes in the social and political scenery of the Western societies since the 70's, whereby interactions among different peoples using different languages is being encouraged (Kolers & Paradis, 1980) as well as due to the relatively recent advances in communication technology, bilingualism is now considered to be the universal norm rather than the exception (Sebastián-Gallés & Bosch, 2001; Segalowitz & Frenkiel-Fishman, 2005; Siegal, Surian, Matsuo et al., 2010).

There has also been a political dimension to research on the effects of bilingualism on cognitive processes, emerging from considerations as to whether bilingual education hampers or advances children's cognitive development. Bilingualism has long suffered criticism as to its claimed negative effects in the mind of bilingual speakers. Viewpoints such as that of Porter (1990), which claims that 30 years of research on bilingualism has shown no vindication for promoting a bilingual curriculum in schools, are ongoing. Consequently, this has lead to voting anti-bilingualism measures in the U.S. (Campbell, 2010; Secada, 1990) and has even created an English-only movement in the U.K., arguing for analogous legislation (Hornberger, 1990).

Research evidence partially supports this view, with studies showing a bilingual disadvantage in tasks of language processing of both languages (e.g. Gollan, Montoya, & Werner, 2002; Ivanova & Costa, 2008; Rosselli et al., 2000; for a review see Mindt, Arentoft, Germano, D'Aquila, Scheiner, Pizzirusso, et al., 2008). For example, bilingual adults show a reduced naming ability in naming tasks compared to monolinguals (Ivanova & Costa, 2008). This bilingual disadvantage seems to be directly related to the level of bilingual proficiency. This is suggested by studies showing that elderly balanced bilinguals perform worse in naming tasks than dominant bilinguals (Gollan et al. 2007). The performance of elderly bilinguals in verbal fluency tasks is also weak compared to their monolinguals counterparts (e.g. Gollan et al., 2007). Additionally, bilingual children seem to have smaller vocabulary size, both productive (Nikoladis & Giovanni, 2000) and receptive (Bialystok & Feng, 2009), when compared with their monolingual peers.

However, there is a growing body of empirical evidence indicating a bilingual advantage over monolinguals in several non-linguistic, cognitive tasks (Bialystok, 2006; for a review see Bialystok & Craik, 2010; Bialystok, Craik, Green & Gollan, 2009; Bialystok, Craik, Grady, Chau, Ishii, Gunji et al., 2005; Bialystok & De Pape, 2009; Bialystok & Martin, 2004; Colzato et al., 2008; Costa, Hernández & Sebastian-Galles, 2008; Festman, Rodriguez-Fornells & Münte, 2010; Hernández, Costa, Fuentes, Vivas & Sebastián-Gallés ,2010; Kharkhurin, 2010; Poulin-Dubois, Blaye, Coutya & Bialystok, 2011). Currently, by integrating all this evidence, belief consensus view that bilingualism results in both non-linguistic benefits and linguistic costs in cognition is starting to emerge (for a review see Bialystok & Craik, 2010).

1.2 Bilingualism and executive control of attention

To illustrate this point, recent research has shown that bilingualism has an effect on executive control of attention. Specifically, bilingual individuals are able to avoid interference of one language while actively enhancing the other linguistic set during communication in one language, which is very likely to be a task that requires executive control (Nardone et al., 2011). This is supported by evidence from models of bilingual speech production, which demonstrate that in order for a word in the desired language to be selected, the analogous competing words in the other language must be inhibited

(Meuter & Allport, 1999; Costa, Santesteban & Ivanova, 2006; Kroll, Bobb & Wondniecka, 2006; Kroll et al., 2008; Finkbeiner, Gollan & Caramazza, 2006). According to models of bilingual lexical access (Costa, Miozzo, & Caramazza, 1999; Dewaele, 2001; Gollan & Acenas, 2000; Green, 1998; Poulisse, 1999) and to empirical evidence (e.g., Colomé, 2001; Costa & Caramaza, 1999; Costa, Miozzo, & Caramazza, 1999; van Heuven, Schriefers, Dijkstra & Hagoort, 2008) both language representations are active during communication in the bilingual mind. Therefore, this form of attentional control is a prerequisite for a bilingual to communicate.

According to neurophysiological evidence from electromagnetic brain studies, bilinguals do not use a cognitive mechanism specifically devoted to this goal, but rather make use of a main executive control mechanism which is responsible for alternating between behavioral tasks (Nardone et al., 2011) to selectively attend to components of the target language and inhibit the non-target language, with the main cognitive functions involved in this mechanism being executive control of attention (i.e. activation of target and suppression of distractor) (for a review see Kroll et al., 2008). This is further supported by neuropsychological and brain imaging studies, which have repeatedly shown that a frontoparietal network involving the dorsolateral prefrontal cortex (DLPFC) and the anterior cingulated cortex (ACC) modulates cognitive control (for a review see Abutalebi & Green, 2008; Botvinick, Braver, Barch, Carter & Cohen, 2001;Bunge, Hazeltine, Scanlon, Rosen & Gabrieli, 2002; Duncan & Owen, 2000). That is, activation of the DLPFC within a wider frontoparietal network is observed in tasks of executive control of attention, in conflict trials where goal-relevant information must be selected and distracting information must be inhibited so that the appropriate response is produced

(Luks et al., 2007; Luks et al., 2010; Kerns et al., 2004; Weissman et al., 2004). More relevant to the cognitive control required in task switching, increased activation of this network has been shown during switch trials of attention-shifting paradigms (Liston et al., 2009; Liston et al., 2006). Similarly in bilinguals, the same neural circuit has been suggested to be involved in language-switching, as activity in this region selectively increases during switching between languages as opposed to non-switching trials (Abutalebi & Green, 2008; Chee, Soon & Ling Lee, 2003; Hernández, Martinez & Cohnert, 2000; Hernández, Dapretto, Mazziotta & Bookheimer, 2001; Nardone et al., 2011; Rodriguez-Fornells et al., 2002). In other words, it seems that a common neural network, involving among others the DLPFC, mediates both executive attentional control of goal-directed behavior, and the ability to switch between two languages (Fabbro et al., 2000; Kerns et al., 2004; Luks et al., 2007; Luks et al., 2010; Nardone et al., 2011; Rodriguez-Fornells et al., 2002; Weissman et al., 2004).

Consequently, neuroanatomical evidence offer grounds for speculating that the benefit of extensive exercise on the ability to shift between two languages, acquired by bilinguals (for a review see Kroll et al., 2008), may transfer to other cognitive non-linguistic tasks requiring executive control. Indeed, empirical evidence is consistent with this hypothesis since several studies have shown that bilinguals are better than monolinguals at resolving cognitive conflict in non-linguistic tasks (Bialystok & De Pape, 2009; Bialystok et al., 2005; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Costa, Hernández & Sebastian-Galles, 2008; Morton & Harper, 2007).

These initial observations have elicited a line of research to study what aspect of executive control of attention is exactly influenced by bilingualism: Is it that bilinguals are more proficient in actually inhibiting the irrelevant information or are they more efficient than monolinguals in enhancing the activation of the relevant language representation? Evidence regarding this question is ambiguous; some studies (e.g., Levy, McVeigh, Marful & Anderson, 2007; Philipp & Koch, 2009) have reported findings in agreement with Green's (1998) Inhibitory Control model of bilingual speech production. On the other hand, other findings (Costa, Santesteban, & Ivanova, 2006) support models of language-specific lexical access of bilinguals (De Bot, 1992; Grosjean, 1997; Paradis, 1989; Poulisse & Bongaerts, 1994), that bilinguals' language-selection mechanism enhances activation only of the lexical representations relevant to the target-language, thus neglecting the distracting translation words and consequently rendering inhibition of those distractors unnecessary (see Costa, 2005 for a detailed discussion on this debate). However, the inhibition hypothesis has received more empirical support (Abutalebi & Green, 2008; see for reviews Bialystok, 2009; Bialystok, Craik, Green & Gollan, 2009; Meuter, 2005).

For instance, bilinguals show a superior inhibitory ability relative to monolinguals in a variety of linguistic and non-linguistic tasks (Festman, Rodriguez-Fornells & Münte, 2010). Zied et al. (2004) employed a bilingual version of the Stroop task, in which French-Arabic adult bilinguals were presented with the typical colour-words conditions (congruent, incongruent and neutral) in French or in Arabic. They found that balanced bilinguals performed equally well in both language versions of the Stroop task. In contrast, dominant bilinguals experienced more Stroop interference in the version of the Stroop test which was written in their less-practiced language (L2), compared to that written in L1. According to the authors, these evidence support the positive relationship between level of bilingualism and the ability to resolve conflict, as the more balanced a bilingual was, the more able he/she was to manipulate the executive control functions tapped by the Stroop test.

More direct evidence on a bilingual benefit in inhibition come from studies of children (for a review of developmental evidence see Bialystok, 2001) and older adults (Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Craik & Luk, 2008; Bialystok, Craik & Ruocco, 2006; Meuter & Simmond, 2007). In these age groups, the function of inhibition is either immature (in children) or declining due to cognitive aging (Bialystok et al., 2009). However, in these studies bilingual children and bilingual elderly were faster in responding to trials tapping inhibition relative to their monolingual peers, thus suggesting a bilingual proficiency in this executive function. For example, in a study using a computerized version of the Stroop task, older bilinguals showed a smaller Stroop effect relative to their monolingual counterparts, supporting a bilingual advantage in executive control of attention. However, the magnitude of the Stroop conflict was increased for both monolinguals and bilinguals when comparing their performance to that of younger participants, thus underscoring the aforementioned declining inhibitory ability of older adults (Bilaystok, Craik & Luk, 2008).

This bilingual benefit in executive control of attention is not limited to the Stroop task, as it has been also demonstrated by a different conflict task, involving inhibition of distractors, the Attentional Network Task (ANT). In Costa and colleagues, a reduced flanker effect was reported for bilingual young adults as compared to monolinguals (Costa, Hernández & Sebastian-Galles, 2008). Additionally, bilinguals’ advantage in inhibitory control has been demonstrated by studies using other non-linguistic tasks, such as the Simon arrow task which involves conflict between the orientation of a target arrow and its position (Bialystok, 2006; Bialystok & Craik, 2010; Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok et al., 2005; Bialystok & De Pape, 2009). The authors found a smaller Simon effect in the bilinguals relative to the monolinguals, either young (Bialystok, 2006; Bialystok et al., 2004; Bialystok et al., 2005; Bialystok & De Pape, 2009) or old adults (Bialystok et al., 2004).

Developmental evidence also indicates a bilingual advantage in executive control of attention. Specifically, in metalinguistic tasks, bilingual children performed better than monolingual children in tasks requiring focusing attention on the relevant information and ignoring the distracting information (e.g. accepting that anomalous sentences such as “Apples grow on noses” are grammatically correct). However both bilingual and monolingual children performed equally in tasks that tap only on grammar knowledge (Bialystok, 1986; Cromdal, 1999). Additionally, research has shown that the ability to solve problems involving conflicting information is developed earlier in bilingual than in monolingual children. For example, in the dimensional change card sort task (Zelazo, Frye & Rapus, 1996), children are asked to sort a set of coloured-shapes cards according to one dimension (e.g. color) and then re-sort them according to the other dimension (e.g. shape). Typically, children as young as 3 or 4 years old continue to sort by the old rule for some trials after the rule changes, even though they are able to correctly state the new rule that they are supposed to sort by. This error has been attributed to children’s difficulty in ignoring the previously relevant features of the stimulus, and not simply to a difficulty in grasping or remembering the new rule (Bialystok, 2009). Clearly then, this task requires effective control of attention to be successfully completed and bilingual children have been shown to solve this executive control “problem” earlier than their monolingual peers (Bialystok, 1999; Bialystok & Martin, 2004). Such a bilingual advantage in executive attention has also been noted in a reversing ambiguous figures task (Bialystok & Shapero, 2005) as well as in Theory of Mind tasks (Bialystok & Senman, 2004). Additionally, bilingual children seem to outperform monolinguals in the trials of the Simon task involving conflict resolution (Martin-Rhee & Bialystok, 2008).

Regarding the “more inhibition or more activation” debate, relevant developmental research offers more support for the inhibition hypothesis. For example, in the study of Carlson and Meltzoff (2008), a battery of executive control tasks were employed to test monolingual and bilingual kindergarten children aged between 4 and 6 years. The majority of these tasks specifically tapped inhibition of attention. These were the Advanced Dimensional Change Card Sort task (Advanced DCCS; Zelazo et al., 1996), thought to involve Perceptual inhibition (Frye, Zelazo & Palfai, 1995; Siegal, Matsuo & Pond, 2010; Zelazo, Frye & Rapus, 1996; Zelazo, Müller, Frye & Marcovitch, 2003), Visually Cued Recall (Zelazo, Jacques, Burack & Frye, 2002) also tapping Perceptual inhibition, Simon Says (Strommen, 1973) tapping Response inhibition and the child version of the Attentional Networks Task (ANT; Rueda et al., 2004) involving Distractor and Response inhibition. Results showed a bilingual benefit in executive functions and specifically in inhibitory control. That is, using factor analysis, the EF tasks were divided into those tapping on Conflict inhibition and those sensitive to Delay inhibition. Bilingual children generally outperformed monolinguals on those tasks that loaded onto Conflict inhibition (i.e. advanced DCCS, Visually Cued Recall), although not in all conflict tasks such as the ANT and the “Simon says” tasks. The authors attributed this lack of a bilingual effect in the “Simon says” and the ANT to the specificity of the bilingual advantage: Since these two tasks involve Response Inhibition, they proposed that the bilingual experience may enhance the ability to inhibit interfering stimuli though not incorrect responses (Carlson & Meltzoff, 2008).

Despite these numerous studies reporting a bilingual benefit in executive control of attention with different tasks, it must be stressed that the specificity of this bilingual effect is yet to be defined as it seems to be difficult to replicate several basic findings “such as the reduced Simon effect in bilinguals …(see Bialystok et al., 2004, for positive evidence based on group differences of several hundreds of milliseconds and Bialystok, Martin, & Viswanathan, 2005, and Bialystok, 2006, for failures to replicate)” (Colzato et al., 2008, p. 302).

1.3 Is there a bilingual effect beyond the Executive Control network of Attention?

Given that bilingualism exerts some kind of influence on the executive attentional network, is there a reason to believe that the alerting and the orienting networks of attention may also be influenced by this factor? Research with monolinguals shows that different attentional functions do influence each other (Hernández et al., 2010). Studies by Callejas and collaborators (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005), combining a conflict-resolution task (to assess the executive attention network) with visual cues (to assess the orienting network) and auditory cues (to assess the alerting network), have demonstrated that: When some trials requiring conflict resolution were preceded by an alerting signal, the conflict effect was larger (i.e. there was a slower RT to resolve conflict and hence select the target correctly) compared to the conflict effect in trials not preceded by an alerting cue (Callejas, Lupiáñez & Tudela, 2004; Callejas et al., 2005). Thus, the alerting network directly affected the operations of the executive attention network.

Additionally, when a visual cue indicated the target's location before target onset, a smaller conflict effect was observed (i.e. there were faster RTs to resolve conflict and thus select the target) compared to trials where the visual cue preceding the target was presented in the opposite location of the upcoming target-stimulus. Thus, the orienting network can also modulate the function of the executive attention network. Finally, a larger orienting effect was elicited in trials whereby an alerting auditory cue preceded the visual orienting cue, in comparison to trials not involving an alerting cue. Thus the efficiency of the orienting network was directly influenced by the alerting network (Callejas et al., 2004, 2005; Fuentes & Campoy, 2008).

That is, these findings suggest that these three networks do not function totally independent from each other. Therefore, it may be that the changes in the function of the executive network produced by the bilingual experience can also influence the function of the other two attentional networks, orienting and alerting (Hernández et al., 2010).

1.4 Bilingualism and the Alerting network of Attention

The term alerting refers to the ability to develop and maintain sensitivity to external stimulation, in an effort to prepare for processing high-priority events (Posner & Boies, 1971; Posner & Petersen, 1990). Behavioral studies typically measure alertness with Reaction Time (RT) tasks, involving trials with a warning cue before target onset and trials with no warning cue. The consistent finding in such tasks is that faster RT are observed in trials with a warning cue relative to RT in trials with no warning cue preceding target onset (e.g. Fan, McCandliss, Sommer, Raz, & Posner, 2002; Posner, 1978; Posner & Boies, 1971; Posner & Petersen, 1990).

To the best of our knowledge, only 2 studies (Costa, Hernández & Sebastian-Galles, 2008; Costa et al., 2009) have tested the possible influences of bilingualism on the alerting network of attention, with contradicting results. In both studies which investigated the possible effect of bilingualism on the alerting function (Costa, Hernández & Sebastian-Galles, 2008; Costa et al., 2009), the Attentional Networks Task (ANT; Fan et al., 2002) was used. In the 2008 study, Costa and collaborators reported a larger magnitude of the alerting effect in bilingual adults relative to monolinguals. That is, although both language groups benefitted from the warning cue, bilinguals responded faster than monolinguals in trials with the presence of an alerting cue. Thus, there appears to be a modulating effect of bilingualism on the alerting network of attention. However in the later study (Costa et al., 2009), alerting did not appear to be modulated by bilingualism as monolinguals and bilinguals were equally facilitated by the alerting cue. No explanation was offered by the authors to reconcile these conflicting findings. Thus more research is needed to conclude whether bilingualism influence or not the alerting network of attention.

1.5 Bilingualism and the Orienting network of Attention

The evidence of an influence of bilingualism on visuospatial attention is both limited and inconsistent (Colzato et al., 2008; Costa et al., 2008; Hernández et al., 2010), and has also produced mixed results. In two (Colzato et al., 2008; Hernández et al., 2010) out of the three studies investigating orienting in bilingual adults, the authors employed the same task: an inhibition-of-return task, in which participants had to make an orientation discrimination response to a line target that could appear in a previously cued or uncued location. The cue was not predictive of the location of the target. The results of Colzato et al. (2008) were rather complicated: They found, as expected, a facilitation effect in the short cue-target interval, but only for the monolingual group. Also, as expected when the cue-target interval was long (700 ms) response times were slower for targets at the cued location relative to the uncued location, the inhibition of return (IOR) effect, but this effect was only significant for the bilingual participants. An explanation from the authors was that perhaps bilingualism improves, or strengthens one's inhibitory ability; therefore, when a stimulus starts to be processed, both facilitatory and inhibitory effects are elicited and the null facilitation effect of bilinguals is the result of their stronger inhibition ability which cancels out any cueing-facilitation effect at that point. On the contrary, given that in longer cue-target intervals the facilitation effect decays, bilinguals' stronger inhibition ability becomes apparent when time lapses hence the IOR effect in long cue-target intervals found only in the bilingual group. However, no explanation was offered as to why an IOR effect was not observed in their monolingual group.

Hernández et al. (2010) failed to replicate these findings, as IOR and cueing facilitation effects were evident and identical for both monolingual and bilingual speakers. Based on these findings and on the ones from the third study which used a different task to look at possible bilingual influences in orienting of attention and specifically in cueing-facilitation (Costa et al., 2008), where the magnitude of such an effect was again identical for both language groups, Hernández et al. (2010) concluded that bilingualism most probably does not modulate orienting of attention and that the results of Colzato and colleagues were not accounted for by the authors.

We suggest that, among other factors, the age of the participants in Costa et al. (2008) and Hernández et al. (2010) could have masked a possible difference in orienting as a function of language experience. That is, developmental evidence argue for age-improvements in orienting of attention (Mezzacappa, 2004), as older children in that study were more facilitated by an orienting cue than younger ones in the ANT. Thus, it could be that the participants of Costa et al. (2008) and Hernández et al. (2010), due to their young age, performed at ceiling in the orienting task and this led to a Type II Error. This however does not account for the differences between the language groups in the Colzato et al. (2008) study. Nevertheless, this leaves open the possibility of detecting influences of bilingualism in orienting in children, where there still is room for improvements in attention. Therefore, given the inconsistent findings regarding a bilingual effect in orienting in adults and the fact that, to our knowledge at least, there is no study on the possible bilingual effects in orienting of children, further exploring a possible effect of bilingualism on the orienting attentional network is considered essential for better explaining the relationship between bilingualism and attentional networks, in both adults and children.

However, a question still remains as to what could account for the discrepancies in the aforementioned (Colzato et al., 2008; Hernández et al., 2010) findings. It is not the task employed, as it was identical in both studies. Could it be then, that differences between the samples have led to different results? Regarding age, all participants were in early adulthood, with a mean age of about 21 years. Monolinguals were all Spanish and not functionally fluent in an L2, as measured by self-administered questionnaires on language use, although all had taken foreign language courses at school mostly. Additionally, all bilinguals in those studies were balanced in L1 and L2 proficiency and use, as evident by the same self-rated questionnaires. Moreover, care was taken to match participants for general intelligence. The role of socioeconomic status (SES) of the participants as a possible confounding though seems to have been overlooked, and this is described in more detail below.

1.6 The role of Socioeconomic Status, culture and level of bilingualism in studies of a Bilingual Effect on Cognition

As mentioned earlier, according to several authors (Morton & Harper, 2007; Colzato et al., 2008) the replicability of studies showing a bilingual effect on attention processes is problematic, as many of them yield inconsistent or even contradicting results. Crucially, in most of these studies the SES level of the participants differed as a function of language group (i.e. bilinguals or monolinguals) or SES was not measured or described (e.g. Bialystok, 1999; Bialystok, 1986, Experiment 1; Bialystok & Martin, 2004; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005; Costa et al., 2008; Hérnandez et al., 2010). Similarly, in developmental studies of the cognitive effects of bilingualism, the participants have not been well matched on SES. More specifically the bilingual children in some of these studies would seem to be of a higher SES than their monolingual peers. For example, according to Morton and Harper (2007), the bilingual children in many studies (e.g. Bialystok, 1999; Bialystok, 1986, Experiment 1; Bialystok & Martin, 2004; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005; Bialystok & Viswanathan, 2009) are from immigrant Canadian families whereas the monolingual children come from non-immigrant Canadian families. In turn, due to the Canadian immigration policy for which strong academic achievement is highly appreciated, Canadian immigrants have a higher average education level than non-immigrants (PCEIP; Statistics Canada, 2003a). Additionally, testing middle or high SES individuals instead of low SES leaves open the possibility that the effects which emerge are exaggerated from SES influences in cognition.

To what extent does SES influence measures of cognitive control in studies of bilingualism? SES has been shown to have a profound impact on the performance of both monolinguals and bilinguals on cognitive tasks (e.g. Carlson & Melzoff, 2008; Mezzacappa, 2004). Low SES seems to have a negative impact on executive function, particularly on attention-related processes. Specifically, the home environment (i.e. the availability of sources of stimulation, including toys, parent-child interaction, and maternal sensitivity) exerts important influences on the development and later performance of basic cognitive functions, one of which is executive attention (Glick, Bates & Yabiku, 2009; Lipina & Colombo, 2009; for a review see Magnuson & Duncan, 2006).

Additionally, the quality of both the home and the school environments, which widely differ according to SES, predicts performance on tasks that tap attention processes such as sustained attention and inhibition (National Institute of Child Health and Human Development and Early Child Care Research Network, 2002). As for the three main attentional networks, alerting, orienting, executive attention, Mezzacappa (2004) has demonstrated that under high-monitoring conditions children of higher SES were superior in speed and accuracy in tasks tapping these three attention functions, compared to children of low SES. Thus, it could be hypothesized that the variability of findings in research into the bilingual advantage in attention might be at least partially attributed to a lack of control for the SES of the participants. Stated more strongly, it may even be the case that the reported bilingual benefit in executive control of attention is attenuated once SES is balanced between the participant groups, as in the study of Morton and Harper (2007).

Therefore, we considered that careful control of SES in all the experiments included in this thesis was crucial. Hence, despite the multidimensionality and complexity of the SES construct (for a review see Hackman & Farah, 2008), we made an effort to adopt a definition that included the basic SES determinants: education and occupation (Braveman et al., 2005; Duncan & Magnuson, 2003; Krieger et al., 1997), as it has been shown that each of these components reflects a different aspect of SES. Specifically in the Greek literature, level of education and parental education in the case of minors (Petridou et al., 1994, 1995, 1996, 1997; Kouri et al., 1995; Laskari et al., 2000; Mergoupis, 2001; Kyriopoulos et al., 2002; Xidea-Kikemeni et al., 2002), and type of occupation (Madianos & Stefanis, 1992; Laskari et al., 2000; Mergoupis, 2001) have been widely used to assess individual SES.

Based on past studies claiming to have used reliable and valid SES measures (Abedi, Lord & Plummer, 1997; Brown, Bown & Eggett, 2009; Costa, Hernandez & Sebastian-Galles, 2008; Garrat & Kelly, 2008; Gullberg & Indefrey, 2003; Portocarrero et al., 2007), we designed a self-reported questionnaire which included items on education level, type of occupation and position in occupation. These provided a combined SES score that categorized the participants as of low, middle or high SES. Similar categorizations of SES according to Occupation Type (e.g. Natsiopoulou & Melissa-Halikiopoulou, 2009) and Education Level (e.g. Benetou et al., 2000) have been repeatedly used by many researchers in Greek samples (for a review see Economou & Nikolaou, 2005). Unfortunately we could not directly measure the other main SES determinant, income, because piloting of the SES measure showed that especially bilingual adult participants found the item on income disturbing.

Culture is another social variable influencing cognitive functions (for a review see Markus & Kitayama, 1991). For example, Chinese preschool children seem to have superior executive functioning (EF) abilities as compared to children from Western cultures. One explanation for this difference in EF is that Chinese culture values and encourages impulse control, which in turn is a central EF characteristic (Chen et al., 1998; Ho, 1994; Sabbagh et al., 2006; Wu, 1996). Interestingly, the bilingual participants in many of the studies of Bialystok and colleagues reporting a bilingual benefit in attention were Chinese or Cantonese, though included only English individuals in their monolingual groups (Bialystok, 2006; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok et al., 2005;).

Thus, it could be that the results on a bilingual proficiency in control of attention reported in those studies are contaminated by the participants' culture, as also suggested by Carlson and Melzoff (2008). To address this issue, in the experiments of the present thesis we tried to balance out any cultural effects by including only participants from collectivist cultures (from Northern Greece and Albania; Eupedia, 2012).

The level of bilingual experience is another factor that has been largely neglected in studies of the cognitive effects of bilingualism. Given that bilingualism is an experience and that experience modifies the cortical centers involved in it (for a review see Bialystok, Craik & Luk, 2012), the level of experience (i.e. for how long and how often a bilingual uses a second language) in bilingualism may well influence its effects in the related cognitive functions (Bialystok, 2009). The role of experience in language switching and executive control is also emphasized by Costa (2005), who argues that increasing experience in switching between two languages may actually change the very nature of language control, with dominant bilinguals using inhibition mechanisms more and balanced bilinguals relying less on such inhibitory functions and more on a more general selection mechanism for effective control of languages, possibly involving other executive control functions.

A question here arises as to which functions exactly could be involved in this “general selection mechanism”. The most obvious answer is that these could be the two other main functions under the umbrella of the executive control construct: working memory and set-shifting (Miyake et al., 2000), as has been previously suggested (Bialystok, Craik & Ruocco, 2006). Therefore, if lifelong bilingualism involves and hence trains these three functions, we could expect balanced bilinguals to excel in tasks tapping a combination of these functions. On the contrary, perhaps less experience in language-switching would be reflected in an advantage in just one of these functions. In other words, differences in bilingual experience may have contributed to the differential behavioral outcomes previously reported. Empirical evidence support this view, with dominant bilinguals excelling in tasks of control of attention (e.g. numerical Stroop: Hernández et al., 2010; flanker task: Costa, Hernández & Sebastian-Galles, 2008) and more balanced ones outperforming monolinguals in tasks not tapping executive attention only, but attentional control in combination to working memory (Simon task: Martin-Rhee & Bialystok, 2008), or attention shifting and cognitive flexibility (card-sort game: Bialystok & Martin, 2004; appearance-reality task: Bialystok & Senman, 2004; a version of an anti-saccade task: Bialystok & Viswanathan, 2009). For example, in Bialystok et al. (2004) a bilingual advantage was present not only for trials involving executive control of attention but also (a) for trials that tapped working memory, (b) for trials assessing a combination of attentional control and working memory abilities and (c) for trials in blocks where frequent response-set switching was required. Importantly, the bilinguals of that study were reported to be balanced in dual-language use. This suggests that perhaps this combination of executive control functions closely resembles the bilingual experience, as apart from inhibiting the irrelevant linguistic set while using the target language, a bilingual also keeps simultaneously two separate linguistic sets active in mind, but also switches between these linguistic sets according to the environmental stimuli triggering either L1 or L2 use, hence the bilingual advantage in attentional control as well as working memory and set-switching.

An additional example is by Costa and Santesteban (2004b), who have showed that balanced bilinguals, as opposed to dominant ones, need not to rely on an inhibition mechanism to switch between linguistic sets as they make use of a qualitatively different selection mechanism for effective language-switching. Similarly, increasing skill in a second language has been empirically related to improvements in more general executive control abilities, specifically involving the functions of executive control of attention, attention shifting and monitoring tapped by a linguistic attention-shifting task (Segalowitz & Frenkiel-Fishman, 2005). That is, following the alternated runs procedure, bilinguals of various proficiency levels were presented either with time-related adverbs (present and past) or with conjunctions (causal and non-causal) in two languages and had to categorize them accordingly. Results showed that the more skilled one was in L2, the faster the attention-shifts in the switching trials of the above categorization task.

These evidence points to two research directions: Firstly, more research is required to further specify whether bilingualism confers an advantage in attentional control alone or in more general executive abilities, given the limited amount of studies investigating this. Secondly, the mechanisms underlying this bilingual effect, if any, need to be further investigated and specifically whether it is the skill of language-switching that is related to the so-called “bilingual advantage” in executive functions. Hence, apart from an exclusively attention task, in the third experiment of this thesis we also included a task assessing more general executive functions which is also relevant to the bilingual experience: The Scalar Implicatures (SI) task. This task requires flexible shifts between the semantic and pragmatic linguistic meaning of a sentence (Katsos & Bishop, 2011). Considering that switching between two languages also requires flexible attention shifting between the two linguistic representations, in a way the SI task resembles the bilingual experience. The evidence on a bilingual influence on SI is scarce and shows that bilingual children outperform monolinguals in SI tasks (Siegal, Matsuo & Pond, 2007; Slabakova, 2009). However, none of the above studies have used a task to empirically relate the bilingual skill of language-switching with the pragmatic competence of bilinguals. To complement for this limitation, we employed a version of Meuter and Allport’s (1999) numerical language-switching task, which can be considered as an index of the bilingual skill of switching between two linguistic sets.

An additional reason of including this task in all the experiments described herein was to address the following issue: Although proficiency in language-switching is likely to be an important factor in the cognitive performance of bilinguals, in the majority of relevant studies a self-report measure was used to define how balanced the bilinguals participants were (e.g. (e.g. Costa, Hernández & Sebastian-Gallés, 2008; Garrat & Kelly, 2008; Portocarrero et al., 2007). Such an approach is problematic, due to existing criticisms regarding the subjectivity of such measures (for a review see Mindt et al., 2008). Thus, the language-switching task of Meuter and Allport (1999) we employed was intended to be a more objective measure of bilingualism. According to the asymmetrical switch-cost hypothesis first proposed by Meuter and Allport (1999), during switching between two languages, an asymmetrical switch-cost is elicited when the respondent is required to switch back to L1. That is, it takes longer to switch back to the dominant L1 than to L2. This has been attributed to inhibition that is required to suppress L1 while communicating in L2. This inhibition is thought to be large due to L1 dominance, and as a consequence persists after switching back to L1. Therefore, the amount of this asymmetrical switch-cost is determined by, and reflects, the dominance level of each language. Thus, we would expect RT for trials switching back to L1 to be longer than RT for L2 switch trials if the participants were dominant bilinguals. On the other hand, if a bilingual is balanced, no such asymmetrical switch-cost should be observed.

Finally, considering that the manifestations of the bilingual advantage could differ according to the number of years a bilingual has been switching between two languages, and that this number increases with the passage of time, we used a lifespan approach in the studies of this thesis, to see whether the years one has been using two languages and thus one’s proficiency in language-switching influences the nature of the bilingual effect. Additionally, this lifespan approach was adopted because we were interested in whether the "bilingual advantage" in the attention system is salient enough to be detected in young adults, who are at the peak of their attentional capacities, or whether it is more subtle and therefore can be only detected in ages where executive functions are either immature (in children) or declining (in older adults) (for a review see Craik & Bialystok, 2006). This difference in the effectiveness of executive functions due to age could be another possible source of variability in the existing cognitive studies of bilingualism and hence was considered important to investigate.

1.7 Research Aims

Given the strong influence of SES on performance on cognitive tasks, in addition to the fact that numerous studies of bilingualism's effects on cognition have either failed to control for SES or have included middle to high SES samples (e.g., university students), both of which could have contaminated their results, in the following four experiments we investigated the efficiency of the three attention networks of bilinguals, in bilingual and monolingual younger and older adults as well as children, with low SES. As a measure of the three main attentional networks, the ANT task (adult ANT; Fan et al., 2002) was chosen, which includes manipulations that tap all three attention systems.

Age was considered to be another important factor contributing to the mixed results on bilingualism and attention. To control for a possible ceiling effect in cognitive tasks due to the age of young adults included in numerous existing studies of bilingualism, we examined age groups from childhood to late adulthood. Another reason for this lifespan approach was to investigate whether the magnitude of the bilingual effect in cognition is influenced by the amount of practice in language-switching which, in early bilinguals, should increase with increasing age.

In order to assess proficiency in language-switching, or level of bilingual skill, we used a version of Meuter and Allport's (1999) numerical language-switching task. This task was also used as a more valid index of language proficiency in bilingual individuals (Costa & Santesteban, 2004; Meuter & Allport, 1999) relative to the self-reported questionnaires on language use that have been used up to date. This measure, in combination to the results from the attention tasks, may also allow us to detect possible relations between level of expertise in language-switching and the main attention functions, in this way further isolating the possible effects of bilingualism in attention. Finally, we aimed at specifying whether bilingualism benefits attention functions alone or in addition to other executive control functions, such as working memory and shifting. For this reason, we also included the SI task (in experiment 3) and a version of the Simon task (in experiment 4) which allowed us to measure executive attention by simultaneously manipulating working memory load.

Chapter 2

The attentional processes of adults bilingual in Albanian and Greek when controlling for sociocultural influences.

Abstract

Evidence shows that in order to communicate efficiently, bilinguals engage daily in language-control to suppress intrusions from the irrelevant language. This can be viewed as a form of cognitive training of the functions involved, which seems to generalize to non-linguistic tasks of executive control of attention, often called a "bilingual advantage". However, past findings on such a bilingual advantage in adults are difficult to replicate. We suggest that this can be attributed to inefficient control of the socioeconomic status (SES) of the participants in those studies. Also, evidence on such a bilingual training effect in all main functions of attention is scarce. In addition, a Reaction Time task was used as an index of bilingual proficiency, as opposed to self-reported measures used by previous studies. Results showed a null effect of bilingualism in the main attention functions when controlling for SES. The implications of these findings are discussed.

2.1. Introduction

Throughout the years, research has tended to indicate that bilinguals are worse in several tasks of language processing compared to monolinguals (for a review see Mindt, Arentoft, Germano, D'Aquila, Scheiner, Pizzirusso, et al., 2008). For example, bilingual adults perform worse than monolinguals in naming tasks, thus showing a disadvantage in lexical competence (Ivanova & Costa, 2008). This reduced naming proficiency seems to be a direct consequence of bilingualism, as elderly balanced bilinguals have been shown to perform worse in naming tasks than dominant bilinguals (Gollan et al. 2007). Elderly bilinguals have also shown weaknesses in verbal fluency tasks compared to monolinguals (e.g. Gollan et al., 2007). Additionally, bilingual children seem to have smaller productive (Nikoladis & Giovanni, 2000) as well as receptive vocabulary (Bialystok & Feng, 2008) than their monolingual peers.

More recent evidence though, supports a bilingual advantage in non-linguistic cognitive tasks (e.g. Bialystok, 2006; for a reviews see Bialystok & Craik, 2010; Bialystok, Craik, Green & Gollan, 2009; Festman, Rodriguez-Fornells & Münte, 2010; Hernández, Costa, Fuentes, Vivas & Sebastián-Gallés ,2010; Kharkhurin, 2010; Poulin-Dubois, Blaye, Coutya & Bialystok, 2011). For example, the performance of bilingual adults has been repeatedly found to be superior to that of monolinguals in various tasks involving executive control of attention, such as the Stroop task (Zied et al., 2004), the Attentional Networks Task (Costa et al., 2009), the Simon arrow task (Bialystok & De Pape, 2009) and the Attentional Blink task (Colzato, Bajo, van den Wildenberg, Paolieri, Nieuwenhuis, La Heij et al., 2008). Additional studies support a bilingual advantage in cognitive control over monolinguals throughout the lifespan (for a review see Bialystok, 2009).

How is bilingualism related to control of attention? According to empirical evidence (e.g., Colomé, 2001; Costa & Caramaza, 1999; Costa, Miozzo, & Caramazza, 1999; van Heuven, Schriefers, Dijkstra & Hagoort, 2008) and to bilingual lexical access models (Costa, Miozzo, & Caramazza, 1999; Dewaele, 2001; Gollan & Acenas, 2000; Green, 1998; Poulisse, 1999), both languages are active while only one of them is being actually used when a bilingual individual is communicating. For the bilingual then to achieve fluent communication in the target language, he/she must resist intrusions from the non-relevant language. In essence then, it is argued (for a review see Bialystok, 2009) that bilingualism constitutes a life-long “cognitive training” in controlling the two linguistic sets.

The cognitive function most relevant to this behavior is executive control of attention, involving the enhancement of activation of the target stimulus (or target language in the case of bilingualism) and the supression of the distracting information (or of the currently irrelevant language), to achieve efficient selection of the target (for a review see Posner & Rothbart, 2007). A question that remains to be answered is whether bilinguals, to achieve target-language production, either activate the target language or suppress the non-target language or both. Significant efforts have been made to address this issue, with some evidence for each viewpoint (for a detailed discussion on this debate see Costa, 2005).

Converging neuroimaging evidence suggest that most possibly inhibition is the cognitive function associated with having command of, and hence using, more than one language. That is, inhibition seems to be the main function modulated by the dorsolateral prefrontal cortex (DLPFC) which, along with the Anterior Cingulate Cortex, constitute the control network responsible for bilingual language-switching (e.g. Abutalebi & Green, 2007; Chee, Soon & Ling Lee, 2003; Hernandez, 2009; Hernandez, Dapretto & Bookheimer, 2001). In turn, the same control network is used in every task requiring cognitive control of attention (for a review see Abutalebi & Green, 2008) and specifically inhibition, hence the bilingual benefit in non-linguistic tasks tapping inhibition (Green, 1998).

Given the mutual influence of the executive control of attention function with the other two main attention functions, those of alerting and orienting (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005; Hernández et al., 2010), it could be that the effects of bilingualism generalize to those two attention processes as well. To our knowledge, only two studies have investigated the possible modulation of either alerting and/or orienting by bilingualism (Costa, Hernández & Sebastián-Gallés, 2008 for executive, alerting and orienting attention functions; Hernández et al., 2010 for the executive and the orienting functions), whose results are mixed. This underlines the need to further explore the workings of all the three main attention networks (i.e. executive attentional control, alertness and orienting; Posner & Petersen, 1990) under the influence of bilingualism (Hernández et al., 2010).

Specifically, Costa, Hernández and Sebastián-Gallés (2008) investigated the possible influences of bilingualism in all three main attention networks. They employed the Attentional Networks Task (ANT; Fan et al., 2002) for this purpose, in a sample of 100 monolingual and 100 bilingual university students, with a mean age of 22 years. The ANT is a reaction time task, whereby the participant is presented with 5 arrows and is asked to respond to the direction of the central arrow by pressing the analogous mouse button. With relevant manipulations, the ANT includes trials tapping the executive control of attention, the alerting and the orienting networks. In that study, bilinguals outperformed (i.e. responded faster than) monolinguals in both conflict resolution trials and in alerting trials. Thus, it was concluded that possibly the bilingual advantage in executive attention may extend to the alerting function. However, there was no difference between monolinguals and bilinguals on trials assessing orienting of attention.

In the study of Hernández et al.'s (2010), again the performance of bilingual and monolingual university students with a mean age of 21 years old was compared. The tasks differed from those of Costa and colleagues (2008) in that Hernández and colleagues used a visual cueing paradigm to measure orienting effects and a numerical version of the famous Stroop task for executive attention (Stroop, 1935). They found no between-group differences in attentional orienting, with similar cueing facilitation and Inhibition of Return (IOR) effects observed in both monolingual and bilinguals in the visual-cueing task. However in the Stroop task, bilinguals responded faster than monolinguals in trials involving incongruent stimuli, hence requiring conflict resolution.

Contrary to the findings of Costa, Hernández and Sebastián-Gallés (2008) though, there was also a bilingual benefit in Stroop-facilitation effects; that is, bilinguals were more aided by congruent cues and hence responded faster in congruent Stroop trials than their monolingual counterparts. Put differently, although both studies investigated the two elements of executive attention, the cueing facilitation and inhibition effects, only one revealed a bilingual benefit in both effects. Thus, it seems that there is an advantage conferred by bilingualism in executive control of attention, though its nature remains to be determined.

The results of Colzato et al. (2008) which contradict those of Hernández et al. (2010) further emphasize the need to disentangle the specific effects of bilingualism in attention. In their study, Colzato and colleagues (2008) employed the same visual-cueing task as Hernández et al. (2010), again in university bilingual and monolingual students. Unlike the findings of Hernández et al. (2010), their bilingual participants demonstrated a stronger IOR effect than the monolinguals and showed no facilitation from spatial cues.

Although all three studies included participants with very similar demographic characteristics and used either similar or identical tasks, their results are largely inconclusive. This agrees with the statement that replication of bilingual effects in attention is sometimes “notoriously difficult” (Colzato et al., 2008, p.302).

To our view, a possible explanation for these discrepancies is that the majority of the studies conducted so far on the effect of bilingualism on attention have not controlled sufficiently for the influences of non-linguistic measures such as socio-economic status (SES) (i.e. either have not matched their participants in SES or have included middle or high-SES individuals), that could provide an alternative interpretation of the bilingual advantage (Morton & Harper, 2007). That is, in the three aforementioned studies, participants were university students, thus probably of middle-to-high SES. This suggests that there could always be the possibility that their results were confounded by the effects of SES on cognition. Similarly, the majority of studies on the cognitive effects of bilingualism have either included university undergraduates (e.g. Bialystok, 2006; Festman, Rodriguez-Fornells & Münte, 2010; Kharkhurin, 2010) or have not measured SES at all (e.g. Bialystok et al., 2005; Bialystik & DePape, 2009; Zied et al., 2004). However, given the important influences of SES in the executive system and especially in attention (for a review see Magnuson & Duncan, 2006), it is hard to disentangle the SES effects from those of bilingualism using these samples.

Studies showing superior performance of higher as opposed to lower SES individuals in tasks of executive control of attention (Mezzacappa, 2004) serve to further support this claim. More importantly there is some evidence, though limited due to the small sample size of that study (N=12 in each language group), suggesting that the bilingual benefit in executive control is indeed attenuated by low SES (Morton & Harper, 2007). Specifically, the performance of bilingual and monolingual children aged from 6 to7 years was compared in the Simon task, assessing executive control of attention (Bilaystok, Craik, Klein & Viswanathan, 2004). The SES (based on a parental report questionnaire), non-verbal intelligence, age and receptive vocabulary of their participants was matched between the language groups. The results showed no differences between monolinguals and bilinguals in the Simon task, thus suggesting that when the participants are matched for SES, the bilingual effect in attention disappears (Morton & Harper, 2007). Therefore, before conclusively suggesting that there is a bilingual benefit on attention, SES should be taken into consideration.

The aim of the present study is (a) to investigate the three attention networks in bilingual and monolingual adults, (b) while controlling for the SES factor. For this purpose, the ANT was chosen (adult ANT; Fan et al., 2002) claimed to validly and reliably assess the three networks of attention (e.g. Rueda et al., 2005).

Another innovation, as compared to previous studies on bilingualism, is the measure of level of bilingualism (proficiency in switching between the two languages) we have employed. Most studies of the bilingual effect on cognition (e.g. Costa, Hernández & Sebastian-Gallés, 2006; Garrat & Kelly, 2008; Portocarrero et al., 2007) have used self-report questionnaires to quantify bilingualism. However, according to the review of Mindt et al. (2008), these measures are subjective to the point that their findings should be interpreted with caution. Thus, we employed a more objective measure of bilingual skill, the numerical language-switching task (Meuter & Allport, 1999).

The logic in using this task was as follows: Meuter and Allport (1999) were the first to demonstrate that the processes of language switching in bilinguals are fundamentally similar to non-linguistic processes of task-switching. That is, Reaction Times (RT) are longer for switch than non-switch trials and most importantly, when the bilingual participant is required to switch back to L1 (i.e. the dominant language) from L2 (i.e. the non-dominant one), an asymmetrical switch-cost is elicited (i.e. larger RT cost than for switching from L2 to L1), attributed to more inhibition that is required to suppress the dominant language than the non-dominant one. In this case, inhibition persists to the switch trial and consequently results to the asymmetrical switch-cost.

However, when the respondent is a balanced bilingual – and when, therefore, neither language is dominant –, the asymmetrical switch-cost is abolished. Subsequent studies (e.g. Costa & Santesteban, 2004) support the robustness of these findings. Thus it seems that the magnitude of the asymmetrical switch-cost in a language-switching task depends on the dominance level of each language (Verhoef et al., 2009). Therefore, a language-switching task serves as an index of bilingual proficiency, expecting less balanced bilinguals to show a larger asymmetrical switch-cost than the more balanced ones. In addition, data from such a language-switching task in combination to data from an attention task could serve to better understand the exact manner in which attention functions are used by bilinguals to manage bilingual language-switching, in this way further elucidating the mechanisms underlying the bilingual advantage (Siegal, Surian, Matsuo, Geraci, Iozzi, Okumura et al., 2010).

Summing up, in-line with previous findings (e.g. Bialystok et al., 2008; Costa, Hernández & Sebastián-Gallés 2008; Hernández et al., 2010), we predicted that bilinguals will resolve conflicting information more efficiently than monolinguals (less interference from incongruent information). Additionally we predicted that, in line with other studies (Bialystok, 2006; Costa, Hernández & Sebastián-Gallés, 2008; Hernández et al., 2010), there will be a bilingual advantage in monitoring processes. In the context of the ANT task, this means that bilinguals will be more aided by an alerting cue (i.e. RT in alerting-cue trials will be faster than RT in no-cue trials) than monolinguals. Finally, no differences among bilinguals and monolinguals in the orienting effect were predicted, in-line with previous research (Costa, Hernández & Sebastián-Gallés 2008; Hernández et al., 2010).

2.2. Method

Participants

A self-reported questionnaire, designed to assess SES and linguistic background, was used to gain more detailed information on the participants' SES level and Language background (see Appendix D), which is described later. The bilingual group included 22 adults (7 males, 15 females) bilingual in Greek and Albanian, with low SES. Their ages ranged from 18 to 48 years old (M=31.23, SD= 9.3). The monolingual group included 20 adults (8 males, 12 females) monolingual in Greek, who were matched on SES to the bilingual group. Their ages ranged from 18 to 61 years old (M= 40.35, SD= 14.25). Additionally, 17 adults (6 males, 12 females) monolingual in Greek, with a middle SES level and a minimum skill in a second language served as the middle-SES group. Their age ranged from 19 to 61 years old (M= 36.71, SD= 12.54).

Bilingual volunteers were recruited from a village near Thessaloniki and from Athens by word of mouth and from an Albanian association in Thessaloniki after a personal contact with the main researcher. Monolinguals were recruited from the experimenter's environment and an adult's night school in Thessaloniki after official contact of the main researcher. Written informed consent (see Appendix B) was obtained from all participants.

Material and Procedure

Each participant was tested individually, in a quiet room. A short description of the study, by withholding the exact aims to avoid demand characteristics, was firstly given, followed by the informed consent. The demographics and language background questionnaire were then be filled in by the participant, with the experimenter present so that any misunderstood question can be explained. The intelligence measures followed (Raven's SPM; WAIS-III Vocabulary test).

Furthermore, the computerized tasks were executed (language-switching as the measure of level of bilingualism; the ANT task). For both tasks, instructions were given orally and in written, and the participants were given enough time to ask for any possible clarifications. The order of task administration was counterbalanced for all participants. Testing lasted approximately 90 minutes for the monolinguals and 105 minutes for the bilinguals.

Demographics and Language background questionnaire

This questionnaire was based on previous studies of bilingualism and its hypothesized effect on cognitive processes, which have demonstrated to reliably and validly measure these demographic and linguistic aspects (Abedi, Lord & Plummer, 1997; Brown, Bown & Eggett, 2009; Costa, Hernandez & Sebastian-Galles, 2008; Garrat & Kelly, 2008;

Gullberg & Indefrey, 2003; Portocarrero et al., 2007). The questions were translated from English into Greek.

The SES section of the questionnaire included items on education level, type of occupation and position in occupation (see Appendix F). Similar categorizations of Occupation Type (e.g. Natsiopoulou & Melissa-Halikiopoulou, 2009) and Education Level (e.g. Benetou et al., 2000) have been repeatedly used by many researchers to assess SES level in Greek samples (for a review see Economou & Nikolaou, 2005). The demographics section included questions on the age, gender and nationality of the respondent. Questions on the language background of the respondent were also included (see Appendix F).

Differences between Language groups in SES level, Language Use & Language Skill

SES level

A one-way between-subjects ANOVA with SES level as the dependent variable and Language group as the between-subjects factor, revealed that SES level differed significantly as a function of Language Group [$F(2, 60) = 5.316$, $p = .008$, $\eta^2 = .926$]. According to planned t-tests, the middle-SES group (M= 7.89, SD= 2.31) had significantly higher SES level than the monolingual (M= 5.9, SD=1.71) and the bilingual groups (M= 6.41, SD=1.82), $p = .008$. There were no significant differences in SES between the monolingual and bilingual groups.

Second Language Use

An ANOVA with Language Use scores as the dependent variable and Language Group as the between-subjects factor, showed significant differences in frequency of use of an L2 according to Language Group affiliation, [$F(2, 60) = 662.301$, $p < .00001$, $\eta^2 =$

.959]. Specifically, bilinguals (M= 4.91, SD= 0.25) reported using a second language far more frequently than the middle-SES (M= 0.58, SD= 0.55) and the monolingual group (M=0.25, SD= 0.15), p< .00001. The differences between the monolinguals and the mixed group were not significant, due to the minimal exposure in an L2 of the middle-SES group.

Second Language Skill

Scores of L2 Language Skill were submitted to a one-way ANOVA, with Language Group as the between-subjects factor. Significant differences between the Language Groups in L2 skill were indicated, [$F(2, 60) = 68.154$, $p < .00001$, $\eta^2 = .705$]. According to planned t-tests, monolinguals (M= 0.2, SD= 0.19) had a significantly lower skill in a second language compared to both bilinguals (M= 4.03, SD= 0.82) and the middle-SES group (M= 2.65, SD= 1.58), p< .00001. Additionally the middle-SES group had a significantly lower second language skill than bilinguals, p< .00001.

In sum, the monolinguals and the bilinguals of the present study were did not differ from each other in SES whereas the middle-SES group was of significantly higher SES. Bilinguals used a second language far more frequently in their everyday lives than the monolinguals and the middle-SES group, with the monolinguals essentially reporting not using an L2. Also bilinguals reported having a much higher proficiency in a second language than the other two groups, with monolinguals reporting almost zero L2 proficiency, although the middle-SES group reported to have a minimum L2 skill. Additionally (see Table 2.3 in Appendix F), although most bilinguals were not "simultaneous bilinguals" (i.e. exposed in L2 at the same age as in L1), they had been exposed to an L2 (Greek) at least from adolescence and had received formal and informal lessons in L2 for a considerable amount of years.

Intelligence and Vocabulary measures

In bilingual studies, it is essential to match participants for IQ (e.g. Colzato et al., 2008). Importantly, a widely used measure of intelligence has not yet been standardized for the Albanian population (e.g. Wasserman et al., 2000; Zimmerman et al., 2006). Thus, following previous studies of the bilingual effect on attention processes (Bialystok & Martin, 2004; Colzato et al., 2008; Treccani, Argyri, Sorace & Della Salla, 2009), Raven's Standard Progressive Matrices (SPM; Raven, 1958) was used to measure general intelligence in adults. Raven's Progressive Matrices is a widely applied (Raven, 2000) and considered a relatively culture-free, reliable and valid measure of Spearman's g (Raven, 2000; Wicherts et al., 2010).

Secondly, as an indicator of vocabulary proficiency, the expressive Vocabulary subtest of the Weschler Adult Intelligence Scale- version III (WAIS-III; 1997) was administered in both languages (i.e. Albanian and Greek). The WAIS has been widely used and standardized for the Greek population (Koulakoglou, 1998), though not for Albanians. To partially compensate for this limitation, a psychologist of Albanian nationality scored the bilingual participants on the Albanian vocabulary test, from their recorded answers.

Computerized tasks

Both the ANT and the Language-switching task were displayed on a 15 inches laptop screen using the E-Prime 1.1 (2002) software.

The ANT task

The ANT was adopted from Fan et al. (2002). The fixation point was a cross (+). The target was an arrow, pointing either left or right. The target was always presented centrally (see Figure 2.1), either alone (neutral trial) or flanked by four identical arrows according to the condition (congruent or incongruent trial). There were 4 cue conditions (see Figure 2.2).

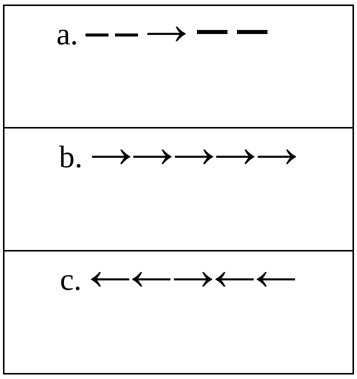

Fig. 2.1. The target (a) neutral condition, (b) flanked by 4 congruent flankers and (c) flanked by 4 incongruent flankers.

Each of the 12 following conditions was equally represented during the task: 4 cue-conditions (central cue, double cue, spatial cue, no cue) x 3 flanker conditions (congruent, incongruent, neutral). Response latencies (RT) and accuracy (errors) were recorded. For a depiction of a typical trial see Figure 2. Completion time was approximately 25min. The experiment included 24 practice trials, providing feedback to the participant, and three experimental blocks with 96 trials each without feedback. In total, 288 experimental trials were presented. Each trial was a combination of one of the 4 cueing conditions (central cue, alerting-sound cue, spatial cue, no cue) with one of the 3 flanker conditions (congruent, incongruent, neutral), and was presented 24 times (8 times in each block). Presentation order of trials was randomized.

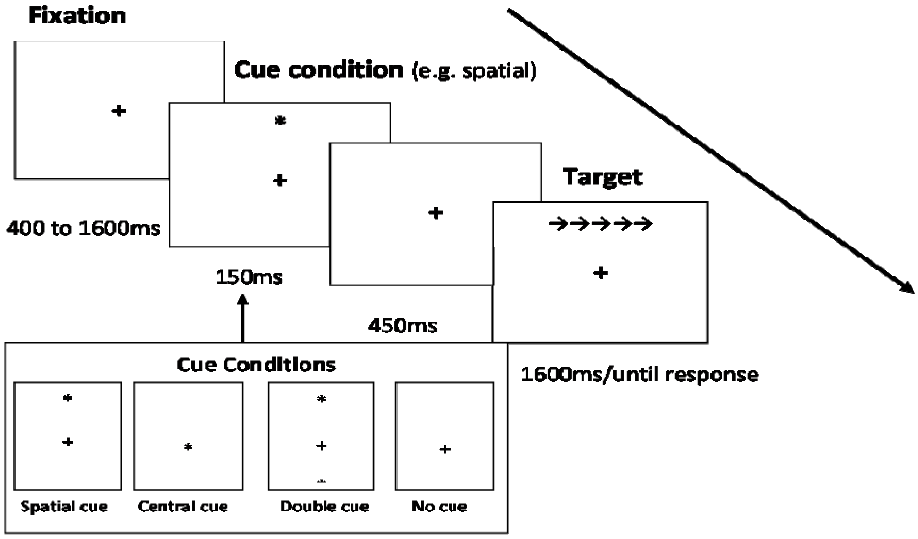

Fig. 2.2. Example trial of the ANT task.

The Language-switching task

This task was based on that of Meuter and Allport (1999). The target stimuli were Arabic digits (1-9). The background was either a Greek or an Albanian flag (depending on the condition) serving as the language cue (i.e. prompted participants to read the digit in either language) (see Figure 2.3). A microphone, connected to a voice key, was used to respond to the target.

Participants were instructed to read aloud the digit on the screen in the language suggested by the language-cue (flag). They were encouraged to respond as quickly and accurately as possible.

Generation of digits was random, with the limitation that no number could be presented twice in a row. Trials were of two types: (1) non-switch trials, where the language of response was the same as in the previous trial (70% of total trials), and (2) switch trials, where the language of response was different than the language used in the preceding trial (30% of total trials). Half of the switch and non-switch trials required a response in L1 and half in L2.

Each trial lasted until response to target and the next trial onset took place 400ms after response (triggering of voice-key). An example of 2 non-switch and 1 switch-trial is depicted in Figure 2.3. Response latencies (RT) were recorded by the software.

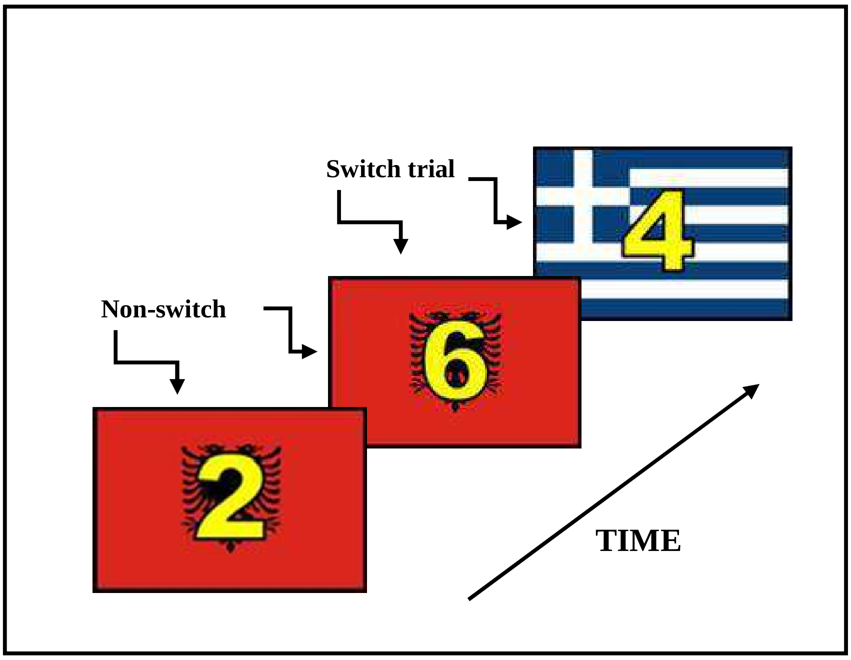

Fig. 2.3. Examples of a non-switch and a switch trial in the Language-switching task

2.3 Results

Intelligence and Language measures

Raven's SPM

Following previous studies (Treccani, Argyri, Sorace & Della Salla, 2009; see also Wasserman et al., 2003; Zimmerman et al., 2006 for application of Raven's SPM in an Albanian sample), and due to lack of Albanian norms for this test, we used participants' raw scores on the Raven's SPM test to make comparisons between the three language groups in general intelligence, entering these data to a one-way ANOVA with Language group as the between-subjects factor (monolingual, bilingual and mixed groups). The ANOVA yielded a marginally significant main effect of general intelligence between the language groups [$F(1, 56)= 2.929$, $p=.062$]. According to planned t-tests between the Language groups, the middle-SES group (M=47.29, SD= 8.17) scored significantly higher in the Raven's SPM test than the bilinguals (M=40.65, SD= 7.41), $t(35)= 2.594$, $p= .014$. No other differences in the Raven's scores reached significance, *ps*> .05.

WAIS Vocabulary subscale

Participants' raw scores on the WAIS Vocabulary subscale (in Greek) were analyzed with a one-way ANOVA, comparing the three language groups. The analysis revealed a significant main effect of language group [$F(2, 56)= 16.453$, $p<.00001$]. Planned t-tests showed that bilinguals (M= 29.05, SD= 16.41) scored significantly lower than both the monolinguals (M= 41.55, SD= 7.80), $t(38)= 3.077$, $p= .004$, and the middle-SES group (M= 49.94, SD= 5.54), $t(35)= 5.004$, $p< .00001$, in the Greek version of this verbal ability test. Moreover, monolinguals scored significantly lower than the middle-SES group, $t(35)= 3.709$, $p= .001$.

The result of significantly lower WAIS Voc. scores of the bilinguals compared to the other two language groups is not surprising. It is in agreement with relevant developmental studies, demonstrating that the typical bilingual child has a smaller vocabulary in one of his/her two languages and a smaller vocabulary in each language individually when compared to that of a monolingual (e.g. Ben-Zeev, 1977; Bialystok, 1988; Nicoladis & Genesee, 1997; Umbel, Pearson, Fernandez & Ollie, 1992), as is the case with bilingual adults (Portocarrero, Burright, & Donovick, 2007). According to the literature, this could be a confounding factor since vocabulary measures have been found to correlate with measures of executive functioning in children (Carlson & Moses, 2001; Carlson et al., 2002). Although there is no reported research on direct relations between vocabulary size and the performance of bilingual adults in non-verbal tasks of executive control, an interaction has been found between reduced vocabulary and verbal tasks of control in bilingual individuals (Bialystok, Craik & Luk, 2008). Therefore, there could be a possibility for lower vocabulary scores to confound with performance on the cognitive tasks we employed. For this reason, in a following secondary analysis of the attention networks as a function of Language group, we covaried the total WAIS Vocabulary scores, as in Carlson and Meltzoff (2008).

The ANT task

Error analysis

A 3 x 4 x 3 mixed ANOVA was used to analyze accuracy scores, with Flanker type (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors and Language group (monolingual, bilingual and mixed) as the between-subjects factor. The main effects of Cue type [$F(3, 324) = 2.809$, $p = .041$, $\eta^2 = .049$] and of Flanker type [$F(2, 324) = 11.929$, $p < .00001$, $\eta^2 = .181$] were significant. The only significant interaction was that between Cue type and Flanker type [$F(6, 324) = 2.302$, $p = .034$, $\eta^2 = .041$]. Most relevant to this study, there was neither a main effect of Language group nor an interaction involving this factor, thus showing comparable correct performance between the groups (monolinguals 97.93%, bilinguals 95.35%, middle-SES 97.87%).

Response Times analysis

Data from 2 bilinguals were eliminated from the analysis as outliers (RTs above 800ms). Thus, the latencies and error rates of 20 bilinguals, 20 monolinguals and 17 middle-SES adults were analyzed. According to Fan et al. (2002) and Rueda et al. (2004), the Conflict effect, reflecting executive control of attention, was calculated by subtracting mean RT in congruent trials from mean RT in incongruent trials. To obtain the Alerting effect, reflecting the alerting attention function, mean RT in double-cue trials were subtracted from mean RT in no-cue trials. Finally, to calculate the Orienting effect, reflecting the orienting network of attention, we subtracted mean RT in spatial-cue trials (i.e. trials were the cue was either above or below fixation) from mean RT in central-cue trials.

A 3 x 4 x 3 mixed ANOVA was used for the initial analysis of mean correct RTs, with Flanker (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors and Language group (monolingual, bilingual and middle-SES) as the between-subjects factor (see Table 2.1). A significant main effect of Flanker was indicated, [$F(2, 106)= 30.155$, $p< .00001$, $\eta^2= .363$], with RTs in the Incongruent condition (M= 725.30, SD= 154.38) being significantly slower than for the Congruent (M= 602.72, SD= 135.90) and Neutral (M= 590.06, SD= 128.30) conditions, $p< .00001$. Thus, a Conflict effect was revealed for all participants. Also RTs for the Congruent condition were significantly slower compared to the Neutral condition, $p< .00001$.

Table 2.1. Means and (Standard Deviations) of RT in milliseconds for each Language group.

Flanker	Language group	Warning cue			
		Central cue	Double cue	No cue	Spatial cue
Congruent	Monolinguals	609.23 (108.13)	597.03 (103.54)	632.71 (100.49)	576.61 (98.07)
	Bilinguals	693.88 (190.24)	651.25 (160.41)	687.98 (164.24)	639.13 (167.88)
	middle-SES	528.64 (92.92)	518.51 (84.23)	552.36 (82.46)	498.38 (90.38)
Incongruent	Monolinguals	749.82 (113.97)	725.24 (111.75)	726.3 (114.89)	669.37 (107.16)
	Bilinguals	814.40 (195.59)	823.06 (182.63)	826.43 (190.61)	758.12 (184.57)
	middle-SES	661.83 (130.29)	642.75 (113.19)	661.18 (112.86)	593.89 (121.57)
Neutral	Monolingual	587.68 (95.13)	586.99 (95.33)	602.8 (86.63)	570.30 (90.66)
	Bilingual	665.39 (168.44)	644.51 (169)	669.21 (159.43)	625.71 (159.96)
	middle-SES	532.76 (89.42)	516.05 (97.93)	548.11 (76.16)	490.24 (83.22)

A main effect of Cue type was also evident, [$F(3, 159)= 6.395$, $p< .00001$, $\eta^2= .108$]. That is, latencies for the Spatial-cue trials (M= 606.36, SD= 135.92) were significantly faster than for the Central-cue trials (M= 653.23, SD= 143.78), $p< .00001$, thus indicating an Orienting effect for all participants. This was also true when comparing performance in the Spatial-cue to the Double-cue (M= 637.87, SD= 136.33), $p< .00001$, and to the No-cue trials (M= 659.98, SD= 133.56), $p< .00001$. Additionally, RTs for the Double-cue trials were significantly faster than for the No-cue trials, *p*< .00001, revealing the presence of an Alerting effect. Also, participants responded significantly faster in the Double-cue compared to the Central-cue trials, *p*< .00001.

The interaction of Cue type by Flanker by Language group was also significant, [F(12, 318)= 1.848, p= .040, η^2= .065]. To further investigate this interaction, we conducted four separate 3 x 3 ANOVAs, one for each cueing condition, with Flanker (congruent, incongruent, neutral) as the within-subjects factor and Language group (monolinguals, bilinguals, middle-SES) as the between-subjects factor. The analysis showed that Language group interacted with Flanker only in the Double-cueing condition, with a magnitude of marginal significance [F(4, 56)= 2.210, p= .073, η^2= .076]. According to Bonferroni post-hoc tests, the middle-SES group responded significantly faster relative to the bilinguals in all Flanker conditions when the cue was Double, *ps*< .05. Nevertheless, the above interaction can be attributed to the larger Conflict effect (RT for Incongruent – RT for Congruent trials) of the bilingual group (M= 171.81, SD= 90.80) compared to both the monolingual (M= 128.21, SD= 76.76) and the middle-SES groups (M= 124.24, SD= 49.15) under the Double-cueing condition.

Because the age range of the participants was wide, in order to control for possible Age effects in our results we then conducted a 3 x 4 x 3 mixed ANCOVA with Flanker (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors, Language group (monolingual, bilingual and middle-SES) as the between-subjects factor and Age as the covariate. The differences in the pattern of the results previously found were limited: firstly, the magnitude of the cueing effect was reduced to marginal significance [F(3, 159)= 2.299, p= .080, η^2= .042]. According to

Bonferroni post-hoc comparisons, this is attributed to the significantly slower responses of all participants to the Central-cue trials (M= 649.103, SD= 143.78) compared to all other cueing conditions, *ps*< .00001. However no other differences between cueing effects reached significance, *ps*< .05. This suggests that Age fluctuations may account for the ANT cueing effects reported in this experiemnt. Additonally, a significant main effect of Language group emerged, [$F(2, 53) = 9.525$, $p < .00001$, $\eta^2 = .264$]. Bonferroni post-hoc tests revealed that this effect is attributed to the overall significantly slower responses of the bilingual group (M= 727.03, SD= 174.42) compared to the monolinguals (M= 619.28, SD= 102.15), *p*= .021, and the middle-SES group (M= 559.85, SD= 97.92), *p*< .00001. There were no other differences in the pattern of results compared to the main analysis.

Finally, to control for a possible confounding effect of lower vocabulary scores of the bilingual group on their performance in the ANT as described earlier, and especially in the trials tapping executive attention, we further conducted a 3 x 4 x 3 mixed ANCOVA, with Flanker type (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors, Language group (monolingual, bilingual and middle-SES) as the between-subjects factor and WAIS total scores as the covariate. The same main effects of Cueing and Flanker were revealed. The difference with the previous main ANOVA was that no interaction reached significance in this analysis.

Detailed assessment of the 3 attentional networks

(a) The executive network of attention (Conflict effect)

For the Conflict effect, a 2x3 mixed ANOVA was conducted, with Flanker type (Incongruent and Congruent trials) as the within-subjects factor and Language group (monolinguals, bilinguals and middle-SES) as the between-subjects factor. The analysis yielded a significant main effect of Flanker [$F(1, 54) = 214.064$, $p < .00001$, $\eta^2 = .799$], with RTs for incongruent trials (M= 714.17, SD= 129.54) being slower than for congruent trials (M= 593.28, SD= 110.24). Thus, a conflict effect was indicated for all participants.

There was also a significant main effect of Language group [$F(1, 54) = 6.494$, $p = .003$, $\eta^2 = .194$], with the middle-SES group being significantly faster overall (M= 581.99, SD= 101.20) than bilinguals (M= 707.67, SD= 121.67), $p = .002$, in responding to either congruent or incongruent trials (see Figure 2.4). The interaction of interest though, among the Language groups and the Flanker condition, did not reach significance.

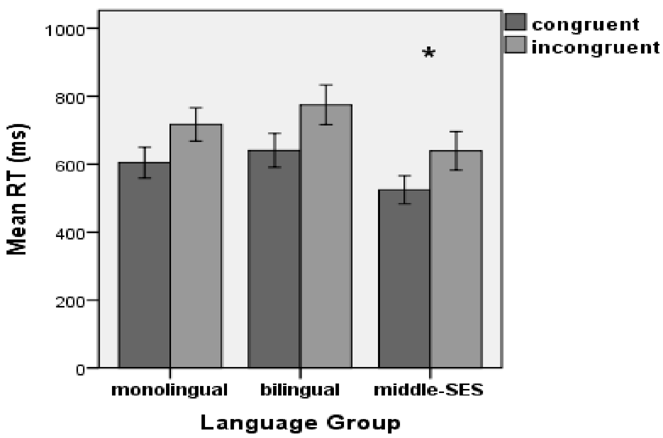

Fig. 2.4. Performance in Congruent and Incongruent trials per Language group. ** sig. at p ≤ 0.05.* Bars represent SE.

To investigate the effect of SES in our overall sample, we conducted a 2 (Flanker type: congruent & incongruent) x 3 (Language group: monolinguals, bilinguals, mixed) mixed ANCOVA with SES as the covariate. The pattern of results remained identical as before controlling for SES.

(b) The alerting network of attention

Data were submitted to a 2 x 3 ANOVA, with Cue Condition (no-cue and double-cue trials) as the within-subjects factor and Language group (monolinguals, bilinguals and middle-SES) as the between-subjects factor. Analysis of mean RTs showed a significant main effect of Language group [$F(1, 54)= 5.681$, $p=.006$, $\eta^2= .174$]. Bilinguals were slower (M= 682.88, SD= 115.81) to respond than the middle-SES group (M= 571.62, SD= 90.42) (see Figure 2.5). The main effect of Cue condition was also significant [$F(1, 54)= 36.025$, $p< .00001$, $\eta^2= .400$], with participants responding faster in double-cue trials (M= 620.806, SD= 110.68) than in no-cue trials (M= 644.35, SD= 109.1). Thus, an alerting effect was indicated as all participants were facilitated by an alerting cue. The interaction between Cue and Language group did not reach statistical significance. When repeating the same analysis but with SES as the covariate, the only difference in the results that emerged was that the cueing effect disappeared, thus suggesting that SES fluctuations may have accounted for the previously significant cueing-facilitation effect of the Alrting cue.

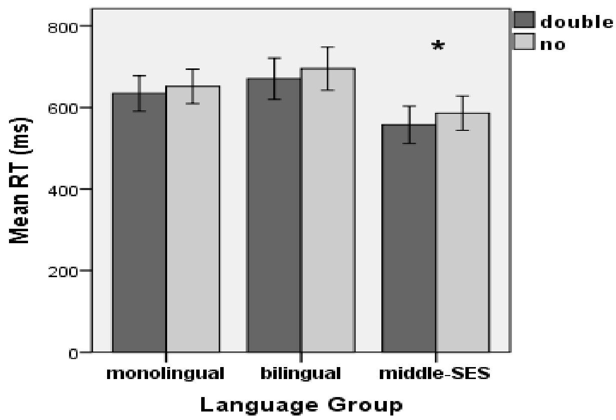

Fig. 2.5. Performance of all Language groups in trials representing the Alerting function of attention.* *sig. at* $p \leq 0.05$. Bars represent SE.

(c) The orienting network of attention

A 2x3 mixed ANOVA was used, with Cue (central and spatial) as the within-subjects factor and Language group (monolinguals, bilinguals and mixed) as the between-subjects factor. A significant main effect of Cue was revealed [$F(1, 54)= 107.328$, $p<.00001$, $\eta^2=$ .665], with responses in trials with a central, non-informative, cue being slower (M= 639.53, SD= 113.98) than responses in trials with a spatial cue (M= 596.05, SD= 113.22), thus indicating an orienting effect independent of Language groups. The main effect of the Language group factor was also significant [$F(1, 54)= 6.082$, $p= .004$, $\eta^2= .184$], as the middle-SES group were faster in responding (M= 549.44, SD= 98.5) than the bilingual participants (M= 667.57, SD= 115.31) (see Figure 2.6). However middle-SES and monolinguals did not differ significantly in these cue conditions. The interaction among Cue and Language group was not significant. When we repeated the same analysis with SES as the covariate, the pattern of results was identical.

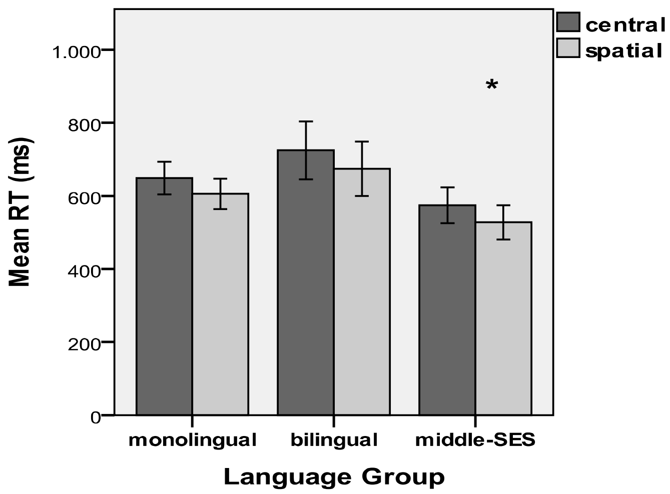

Fig. 2.6. Performance of all Language groups in trials representing the orienting function of attention.* *sig. at* $p \leq 0.05$. Bars represent SE.

Language-switching task

Data from 18 bilinguals were analyzed, as 2 participants did not complete this task. Mean RTs from the Language-switching task were submitted to a 2x2 within-subjects ANOVA, with Trial Type (switch and non-switch) and Trial Language (Albanian and Greek) as the within-subjects factors. There was a significant main effect of Trial Type,

[$F(1, 17) = 49.295$, $p < .00001$, $\eta^2 = .727$], with faster RT in non-switch (M= 754.17, SD= 165.43) compared to switch trials (M= 841.318, SD= 180.35). No other main effect was significant. There was no significant interaction between Trial Type and Trial Language. Paired t-tests showed that RTs in trials switching from L2 to L1 were not significantly different from RT in trials switching from L1 to L2. Put differently, an asymmetrical switch-cost was not observed, which suggests that the bilinguals included in this study were balanced bilinguals.

The Language-switching task may be used to see whether the mechanisms used for switching between languages is similar to those used in non-linguistic tasks involving executive attention. Thus, we reasoned that the task could detect possible relationships between language-switching and resolving conflicting information as indicated by the ANT. Specifically, we wanted to see whether the switch-cost assymetry (SCA) that arises when switching between languages (i.e. the absolute mean RT to switch back to L2 minus the absolute mean RT to switch back to L1) would be correlated to the Conflict effect from the ANT. Additionally, given that the three main attention functions are interrelated (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005; Hernández et al., 2010), we speculated that maybe correlations will emerge between the Conflict, the Alerting and the Orienting effects.

To test for these assumptions, we submitted the SCA, the Conflict, the Alerting and the Orienting effects to a correlation analysis, applying the Bonferroni correction to adjust the significance level for multiple comparisons (see Table 2.2). Alerting was significantly and negatively correlated with Orienting, $r(18) = -.569$, $p = .009$, showing that the more facilitated the participants were from an alerting cue, the slower they were to respond to an Orienting cue. This suggests that Alerting had a negative consequence on the Orienting attention function. Conflict was not related to SCA. This was the case even when controlling for SES.

Table 2.2. Inter-correlations for measures of SCA, Conflict, Alerting and Orienting.

	Conflict	Alerting	Orienting	SES
SCA	-.376	.080	.040	.144
Conflict		-.209	.164	.032
Alerting			-.569*	.177
Orienting				-.133
controlling for SES				
SCA	-.386	.060	-.013	
Conflict		-.202	.210	
Alerting			-.622*	

**** sig. at p ≤ 0.013 (Bonferroni correction)***

2.4 Discussion

The main aim of this study was to determine whether there is a bilingual effect in the three main attention functions of adults when controlling for the influences of SES. The expected bilingual advantage in monitoring processes was not found, since the magnitude of the alerting effect did not differ among language groups. This contradicts the results of several studies (Bialystok, 2006, Costa, Hernández and Sebastián-Gallés, 2008; Hernández et al., 2010). The groups were not matched for SES in those studies and their participants seemed to be of middle-to-higher SES, however all our bilingual and monolingual participants were of low SES. Thus it could be the case that, as suggested by Morton and Harper (2007), matching the groups for SES and especially including bilinguals of low SES attenuates the so-called “bilingual advantage” in the alerting function of attention.

Regarding the executive attention network, bilingualism did not seem to directly modulate this attentional system either, since the magnitude of the conflict effect did not differ significantly as a function of language group. This is in contrast to the results of numerous studies (e.g. for a review see Bialystok et al., 2009; Costa, Hernández & Sebastián-Gallés 2008; Hernández et al., 2010. This could be attributed again to the low SES of our bilingual participants. Most importantly, the fact that the middle-SES group outperformed the other two groups, of low SES, in the trials involving the two main aspects of executive control of attention (i.e. the facilitation effect in the Congruent trials and the inhibition effect in the Incongruent trials) suggests the effect of SES on executive attention.

Alternatively, this speed advantage of the middle-SES group in trials of executive control of attention could be interpreted in the frame of a general response-speed effect of SES in computerized tasks, as it was also observed under all cueing conditions. That is, it is possible that low SES individuals have poorer computer skills than middle SES people, given the typically manual nature of low SES occupations. If that is the case, then it may be that the SES differences in our sample include differences in computer familiarity. In support of such a view, computer familiarity is thought likely to influence performance in computerized cognitive tasks (e.g. Bialystok, 2006; Hérnandez et al., 2010). Previous research has shown a general speed-advantage of bilinguals in tasks of executive control, in both Congruent and Incongruent trials, and has attributed it to an increased efficiency of bilinguals in responding to conditions requiring control of attention (Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Martin & Viswanathan, 2005). However, bilinguals and monolinguals were neither matched for SES in these studies, nor of low SES. Thus, it could be that this speed-of-response advantage reported there reflects the confounding effect of SES and not a beneficial influence of bilingualism.

With regards to bottom-up orienting of attention, bilingualism did not play a role as all language groups showed a quite similar orienting effect. This provides further evidence to support the view that bilingualism does not modulate stimuli-driven orienting of visual attention (Costa, Hernández & Sebastián-Gallés, 2008; Hernández et al., 2010).

Despite the absence of a bilingual advantage in the main attention networks, it seems that bilingualism modulated the interactions between these networks and specifically between Alerting and Executive Control of attention. That is, under the Double-cueing condition which elicits alerting, bilinguals showed a Conflict effect of a larger magnitude (i.e. they were slower to resolve conflict) relative to the other groups. This could be interpreted either as a negative or as a positive consequence of bilingualism. On the one hand, one could suggest that this shows the inability of bilinguals to flexibly make use of two attention networks simultaneously, Alerting and Executive Control of attention, in contrast to the monolinguals. On the other hand, this shutting-down of the Executive attentional Control network in the presence of an Alerting cue in bilinguals could serve an adaptive role: According to neuroimaging evidence (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005, Hernández et al., 2010; Fuentes, Vivas**,** Langley, Chen, & Gonzales-Salinas, 2011) under alertness conditons, the right frontal cortex (which is part of the alertness network) is activated while the anterior cingulated (which is part of the executive attention network) is deactivated. The adaptive value of this inhibitory connection between Alerting and Executive Control of attention could be that in this way, the system prioritizes the detection of the upcoming stimulus (which is the role of the Alerting system) instead of further engaging in the elaborate procressing of that stimulus (the role of Executive Control of attention) with the danger of missing a possible threat that will follow. However, further research is needed to establish the functional role of this inhibitory relationship between these main attention networks.

A secondary aim of this study was to use a language-switching task as a more objective measure of bilingual skill compared to self-reports. As suggested by the questionnaire on Language background, the bilinguals of this study were balanced. This was further supported by the Language-switching task, for which response latencies to switch to L1 did not differ from those required to switch to L2. Thus, an asymmetrical switch-cost was not observed. Therefore, we can safely conclude that the bilingual participants of the present study were indeed balanced. Data from the language-switching task were also used to see whether the mechanisms used to switch between languages are related to those used to resolve non-verbal conflicting information. The results did not support this assumption. However, an interesting negative relationship emerged between the alerting and the orienting attention functions, such that under alerting conditions the Orienting effect was smaller. This penalizing effect of the Alerting on the Orienting attention network is opposite to that previously reported (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005; Fuentes & Campoy, 2008). Unfortunately, no plausible explanation for our contradicting findings can be offered at this point.

The effects that Age had in our results should also be mentioned. That is, when we conducted the main RT analysis with Age as the covariate, results showed slower RT of the bilinguals relative to the other two groups as well as cueing effects of only marginal significance. This suggests that when controlling for Age, bilingualism seems to modulate overall task performance in the ANT by slowing down bilinguals' responses thus showing a penalizing bilingual effect. In addition, it seems that the attentional cueing effects are influenced by age, as previously reported (see Mezzacappa, 2004 for developmental evidence on age influences on the ANT effects). Thus, in orser to minimize such extraneous influences on the results of future studies on attention and bilingualism, it may be wise to limit the age range of their participants.

A limitation of the present study is its rather small sample size. Power analysis indicated that we should aim for a power estimate of 0.95, and that level of power would require a total sample size of 66 participants. Instead, we included 57 participants. Given that our results clearly contradict those of numerous other studies on the effect of bilingualism on attention, and that this is the first time that all 3 attention functions are measured in adult bilinguals with low SES, we consider it important for future studies to increase their sample size.

Another limitation was that the Raven SPM, as well as of any other widely used measure of general intelligence has not been standardized for the Albanian population (e.g. Wasserman et al., 2003; Zimmerman et al., 2006). The fact that the middle-SES group scored higher than the bilinguals in the Raven's test, could be attributed to the marked differences between these groups in SES level, as the effect of SES on Raven's scores has been acknowledged in the past (Raven's SPM, 2003).

Regarding the differences found between all language groups in vocabulary, as measured by the WAIS Vocabulary test- Greek and Albanian versions, this is an expected finding in studies on bilingualism (Portocarrero, Burright, & Donovick, 2007). However, research suggests that performance in executive control tasks in children (Carlson & Moses, 2001; Carlson et al., 2002) and in verbal tasks of executive control in adults

(Bialystok, Craik & Luk, 2008) is directly related to vocabulary size. Therefore, we covaried the WAIS Vocabulary scores on our main RT analyses to control for any possible effect of decreased vocabulary of our bilingual participants.

Concluding, with this experiment we have shown for the first time that SES may attenuate the so-called “bilingual effect” in all three main attention functions and have also provided a demonstration of the effect of SES on these functions. A next step could be to test bilingual and monolingual children of low SES with the same tasks, adapted for children, to see whether the “bilingual effect” on attention is attenuated by low SES also in children, who have been exposed to a low SES environment for considerably less years than adults have. This could offer a lifespan trajectory of the “bilingual effect” on the three main attention processes.

Chapter 3

The attentional processes of children bilingual in Albanian and Greek, of low socioeconomic status.

Abstract

Recent research shows that bilingual children seem to be more proficient in resolving cognitive conflict relative to their monolingual peers. Their constant need to control two linguistic sets has been suggested to account for this bilingual advantage. However, the replicability of such findings has been questioned. Poor control of participants' socioeconomic status (SES) may account for this. Also the possible influences of bilingualism in the alerting and orienting attention functions have not been studied up to date. Two experiments are reported, in which low-SES bilingual and monolingual children were included. In both experiments, the Attentional Networks Task (ANT) was used to assess the there main attention functions of children, executive control, alerting and orienting. A language-switching task was also introduced as a more objective measure of bilingual proficiency relative to parental self-reports that previous studies have used. This also served to reveal possible relations between the mechanisms used to control bilingual children's attention and those used to switch between two linguistic sets. The results of the first experiment showed no modulation of the main attention functions of low-SES children by bilingualism and further suggested that a task more relevant to the bilingual experience of language-switching may reveal the bilingual effect in cognition. Thus, in the second experiment the Scalar Implicatures task was also employed. No differences between monolingual and bilingual children were indicated in any task. However, a subtle bilingual effect was observed in bilinguals' ability to resolve

conflict. Finally, some interesting relationships between the main attention networks were observed.

3.1. Introduction

A bilingual advantage in non-linguistic cognitive tasks has often been reported in adults, specifically in tasks involving cognitive control processes (e.g. Bialystok, 2006; Bialystok & Craik, 2010; Bialystok et al., 2005; Bialystok et al., 2009; Bialystok & De Pape, 2009; Colzato et al., 2008; Costa, Hernández & Sebastian-Gallés, 2008; Fernandes et al., 2007; Festman, Rodriguez-Fornells & Münte, 2010; Hernández et al., 2010; Kharkhurin, 2010). Thus, a question arises as to whether bilingualism influences cognitive functions of the developing mind in a similar manner as those of a developed one.

For instance, one may predict that the bilingual effect in children may be greater than in adults since the former are not at the peak of their cognitive control abilities (for a review see Craik & Bialystok, 2006). Thus, the lack of bilingual effect on executive control of attention previously reported in young adult samples (e.g, Bialystok, Martin & Viswanathan, 2005) could be attributed partly to a ceiling effect. Ceiling effects are known to lead to Type II errors, by reducing the variance in the dependent variable, hence masking the possible effect of the independent variable (Cramer & Howitt, 2005), in this case of bilingualism. A similar argument has been put forward in studies looking at bilingualism in old adults who are also not at the optimal level of their executive attention capabilities (Craik & Bialystok, 2006). In this case, the bilingual benefit may function as a buffer against cognitive decline in elderly bilinguals.

Several studies indeed have reported better performance on tasks specifically involving executive control of attention in bilingual children as compared to their monolingual peers (e.g. Bialystok, 1999; Bialystok, 2010; Bialystok & Martin, 2004; Bialystok & Shapero, 2005; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008; Poulin-Dubois et al., 2011). The main explanation for this bilingual benefit in non-linguistic tasks of executive control of attention, is that the control mechanisms used for effective language-switching are the ones generally used in any task requiring control of attention. This is confirmed by neuroimaging data with bilingual participants (Abutalebi & Green, 2007; for a review see 2008; Chee, Soon & Ling Lee, 2003; Hernandez, 2009; Hernandez, Dapretto & Bookheimer, 2001), demonstrating that a frontal network, and specifically the dorsolateral prefrontal cortex (DLPFC) and the Anterior Cingulate cortex (ACC), is the main brain structure modulating language-switching but also non-linguistic executive control of attention and task-switching.

Using a metaphor, if we assume that control of attention is executed by a muscle, this muscle is well trained by the bilingual experience during the exercise of language-switching and hence performance in any other exercise which uses this muscle (e.g. exercises involving attention shifting, inhibition of distractors etc., such as a flanker task or the Simon task) is also enhanced. In this sense, bilinguals go through a lifetime of training in using selective attention, involving inhibition of irrelevant and activation of relevant information (Neill, 1977), which seems to generalize to other non-linguistic tasks taping on executive control of attention.

Why is attentional control involved in language-switching? According to models of bilingual lexical access (Costa, Miozzo, & Caramazza, 1999; Dewaele, 2001; Gollan & Acenas, 2000; Green, 1998; Poulisse, 1999) and to empirical evidence (e.g., Colomé, 2001; Costa & Caramazza, 1999; Costa, Miozzo, & Caramazza, 1999; van Heuven, Schriefers, Dijkstra and Hagoort, 2008) it is now widely accepted that both languages are active in the bilingual mind while only one is being used. Consequently, in order to effectively communicate in one language, executive control of the linguistic sets is necessary, so that the irrelevant-to-the-current-context language is inhibited and does not interfere with response selection processes. However there is some controversy regarding whether this bilingual control of languages actually requires inhibition of the irrelevant language, as argued by Green's (1998) Inhibitory Control model and by relevant studies (e.g., Levy, McVeigh, Marful, & Anderson, 2007; Philipp & Koch, 2009), or simply more activation of the target language, in-line with models of bilingual lexical access (De Bot, 1992; Grosjean, 1997; Paradis, 1989; Poulisse & Bongaerts, 1994) and with other empirical evidence (Costa, Santesteban, & Ivanova, 2006; see Costa, 2005 for a detailed discussion on this debate).

Although there is evidence to support both views (Costa, 2005), the inhibition hypothesis has received more empirical support. For instance, studies have shown that words from the inappropriate-for-the-context language may intrude speech in bilinguals (Bialystok, Craik, Green & Gollan, 2009). These intrusions may be explained in terms of a failure of attentional control, and support the need of inhibition to keep the non relevant language from interfering with speech. Interestingly, these intrusions have been reported mostly in bilingual children (Bialystok, 2001) and old adults (Sandoval, 2010). Again, in agreement with the inhibition hypothesis of bilingual control, evidence supports that executive control, and specifically inhibition, is not as efficient in these two populations due to a later developmental maturation and decline with age of the neural networks subserving these processes (Craik & Crady, 2002; Diamond, 2002; Raz, 2000).

Further evidence in favor of the inhibition hypothesis come from Carlson and Meltzoff (2008), who used a battery of executive control tasks to test monolingual and bilingual kindergarten children aged from 4.8 to 6.9 years. Most of these tasks, beyond measuring executive functions in general, tapped specifically inhibition of attention. These were the Advanced Dimensional Change Card Sort task (Advanced DCCS; Zelazo et al., 1996), probably involving Perceptual inhibition (Frye, Zelazo & Palfai, 1995; Siegal, Matsuo & Pond, 2010; Zelazo, Frye & Rapus, 1996; Zelazo, Müller, Frye & Marcovitch, 2003), Visually Cued Recall (Zelazo, Jacques, Burack & Frye, 2002) also involving Perceptual inhibition mostly , Simon Says (Strommen, 1973) tapping Response inhibition and the child version of the Attentional Networks Task (ANT; Rueda et al., 2004) involving Distractor and Response inhibition.

Results showed a bilingual benefit in executive functions and specifically in resolving conflict. That is, using factor analysis, the EF tasks were divided into those tapping on conflict and those sensitive to delay of gratification. Then, two composite scores were computed, one for conflict and one for delay scores. Bilingual children outperformed monolinguals in the composite for conflict, although not in all tasks tapping inhibition such as the ANT and the “Simon says” tasks. This was taken as evidence on the specificity of the bilingual benefit, claiming that bilingual experience may enhance the ability to inhibit misleading stimuli, not incorrect responses as in the ANT and the “Simon says” (Carlson & Meltzoff, 2008). However, these findings should be cautiously interpreted, as the sample size of the bilingual group was quite small (N= 12 children). Most importantly, as also stressed by the authors, the groups were not balanced in sociodemographic correlates of cognitive function such as socioeconomic status (SES).

Unfortunately, in most of the studies reporting a bilingual advantage of children in cognitive control, SES was not properly measured or controlled for (Bialystok, 1986, Experiment 1 & 2; Bialystok, 1988; 1999; Bialystok & Martin, 2004; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005). This is an important shortcoming since there is evidence (Morton & Harper, 2007) suggesting that SES may account for the bilingual effect specifically on executive control of attention.

Morton and Harper (2007) conducted one of the few studies to investigate the bilingual effect on executive attention by matching the participants for (low) SES. They employed the Simon conflict task in 6 to 7 year-olds, monolinguals and bilinguals, and matched their participants on SES (based on a parental report questionnaire), non-verbal intelligence, age and receptive vocabulary. The authors found the typical Simon effect, response times were faster for congruent trials (the location of the stimulus was congruent with the location of the key response) relative to incongruent (the location of the stimulus and the response key were incompatible), but there was not an interaction with the Language group (monolinguals vs. bilinguals).

The authors concluded that, given the crucial influences of SES on the development of the attention (Bakeman & Adamson, 1984; Landry & Chapieski, 1989; Linver *et al*., 2002; Kochanska *et al*., 2000), that previous studies arguing for a bilingual benefit in control of attention have not considered the SES level of their participants (Bialystok, 1988, 1999, 2001; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok & Shapero, 2005; Martin & Bialystok, 2003), and that their study involved only low-SES children and found no bilingual effect in attention, most probably it is the lack of control for SES influences (either by not matching the participants for SES or by including middle or high-SES individuals) that can be accounted for the previously reported "bilingual advantage".

The profound impact an environmental factor such as SES can have not only on executive attention, but also on other functions of attention (for a review see Magnuson & Duncan, 2006) in children has been demonstrated by another study conducted by Mezzacappa (2004). Mezzacappa showed that under high-monitoring conditions, children of higher SES were superior in speed and accuracy in tasks tapping executive control, alerting and orienting of attention, compared to children of low SES.

All these findings together suggest that the bilingual advantage reported in many studies with children, and adults, may have actually reflected an SES effect, since bilingual participants have usually a higher SES. For example, according to Morton and Harper (2007), the bilingual children in the majority of these studies (e.g. Bialystok, 1999; Bialystok, 1986, Experiment 1; Bialystok & Martin, 2004; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005; Bialystok & Viswanathan, 2009) are from immigrant Canadian families whereas the monolingual children come from non-immigrant Canadian families. In turn, due to the Canadian immigration policy, according to which academic achievement is a basic requirement, Canadian immigrants have a higher education level than the vast majority of non-immigrants according to the 2003 Report of the Pan-Canadian Education Indicators Programme (PCEIP; Statistics Canada, 2003a). In support of this suggestion, we found that the bilingual advantage was not observed in a sample of bilingual and monolingual adults when we matched the groups for SES. Actually, our bilingual participants were Greek-Albanians immigrant with a low SES (Experiment 1).

Another factor that has been generally neglected in studies of bilingualism is bilingual proficiency (in switching between languages). If bilingualism is seen as an experience, its effect on the cognitive system will vary depending of the level of experience, that is how often the individual uses both languages and need to exert control (Bialystok, 2009). In most of these studies it has been assumed, based on self-report measures, that participants were fully bilinguals and used both languages regularly (e.g. Garrat & Kelly, 2008). However, the subjectivity of such self-report measures may seriously undermine their reliability (for a review see Mindt et al., 2008). This may be particularly important in young children who have not received substantial formal education, and thus may use mainly one language (e.g., the language that is used mostly at home). In order to address this issue in the present study we employed an objective measure of bilingualism, the amount of asymmetry in the cost between switching from one language to the other. According to the asymmetrical switch-cost hypothesis first proposed by Meuter and Allport (1999), the magnitude of the asymmetrical switch-cost elicited in a language-switching task when the respondent is required to switch back to L1, depends on the dominance level of each language. Thus, we would expect RT for trials switching back to L1 (in this case Albanian) to be longer than RT for L2 switch-trials if the participants were dominant bilinguals. On the other hand, should our bilingual participants be balanced, no such asymmetrical switch-cost should be observed.

The importance of level of bilingual switching-proficiency is further underscored by Costa (2005), arguing that increasing experience in switching between two languages may actually change the very nature of language control. More specifically, the more balanced a bilingual is, the less the need to rely on inhibition mechanisms to control the two language representations; instead, probably a more general selection mechanism which is more language-related is used. Neuroimaging data showing that differential levels of bilingual experience are reflected in different increases in brain's grey matter in the left inferior parietal cortex (Mechelli et al., 2004) further underline the crucial role of amounts of experience in modifying bilingual behavior. We considered this to be an additional reason for including a more objective measure of bilingual proficiency, but also for the mixed findings regarding research on the cognitive effects of bilingualism.

That is, in some studies (Bialystok & Martin, 2004; Bialystok & Senman, 2004; Martin-Rhee & Bialystok, 2009; Morton & Harper, 2007) children seem to be balanced bilinguals. However, other researchers seem to have included dominant bilinguals (e.g. Bialystok & De Pape, 2009; Hernández et al., 2010). These differences in language proficiency may have contributed to the differential behavioral outcomes in the tasks used, with dominant bilinguals excelling in tasks of control of attention (e.g. numerical Stroop and visual cueing task: Hernández et al., 2010) and more balanced ones outperforming monolinguals in tasks tapping more general executive control processes, involving attentional control as well as working memory (Simon task: Martin-Rhee & Bialystok, 2008), or attention shifting and cognitive flexibility (card-sort game: Bialystok & Martin, 2004; appearance-reality task: Bialystok & Senman, 2004; a version of an anti-saccade task: Bialystok & Viswanathan, 2009).

Thus, we reasoned that in order to disentangle whether bilingualism confers an advantage in attentional control alone or in more general executive abilities, and whether this is related to the level of switching-proficiency, we also included a task assessing more general executive functions which is relevant to the bilingual experience: The

Scalar Implicatures (SI) task. This task requires flexible shifts of attention between the semantic and pragmatic linguistic meaning of a sentence. In addition, properly computing a scalar implicature seems to also involve Working Memory (De Neys & Schaeken, 2007). Considering that switching between two languages also requires flexible attention shifting between the two linguistic representations and that WM is one of the main EF components (Miyake, Friedman, Emerson, Witzky, Howerter & Wager, 2000), in a way the SI task resembles the bilingual experience and was hence included in Experiment 2.

To sum up, in the present study we aimed at investigating the effect of bilingualism on attention and related executive functions in children of a low SES. We also investigated the relationship between bilingual proficiency and the nature of the bilingual effect.

Experiment 1

A bilingual advantage on executive control of attention in children has often been reported (e.g. Bialystok, 1999; Bialystok, 2010; Bialystok & Martin, 2004; Bialystok & Sapiro, 2005; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008; Poulin-Dubois et al., 2011). Although our results of our previous experiment involving low SES adults contradicted these findings, we assumed that the bilingual benefit in performance will be more salient in childhood than adulthood, thus predicted that bilingual children of low SES will resolve conflicting information faster than their monolingual peers of equally low SES .

Given the lack of previous empirical evidence on the alerting function of bilingual children, and the strong influence of SES on the developing alerting system (Mezzacappa, 2004), we predicted that there will be no bilingual advantage in monitoring processes once SES effects are eliminated. In the frame of the ANT task, this means that low SES bilinguals will be equally aided by an alerting cue (i.e. RT in alerting-cue trials will be faster than RT in no-cue trials) as low SES monolinguals.

Again we lack previous evidence on the orienting function of bilingual children. Thus, in line with the evidence on the devastating effects of low SES on children's orienting ability (Mezzacappa, 2004), we predicted that there will be no differences among bilinguals and monolinguals of low SES in the orienting effect.

3.2. Method

Participants

Inclusion criteria were a signed parental consent form, age between 6 and 12 years, coming from a low SES parental background (as defined by the Demographics and Language Background questionnaire, see Appendix E), a normal general IQ score (as defined by the Raven's CPM) for the monolingual Greek children and a matched score for the bilingual Albanian children given the lack of norms for the Albanian population (Wasserman et al., 2003; Zimmerman et al., 2006), of Greek ethnicity and speaking only Greek at home and at school (for monolingual children) or of Albanian ethnicity, speaking Albanian and Greek approximately equally in everyday life and being exposed in the two languages from at least 2 years of age (as defined by the Language Background questionnaire). Also, bilingual children had to be able to count from one to nine in both Greek and Albanian.

Although 32 bilingual children were tested, only data from 26 bilingual children were included in the analysis, because 2 children could not execute the Language-switching task (they reported they could not name the numerals in Albanian, although both their parents and siblings were Albanian and the children were born in Albania), one child fell ill during the experiment and did not want to complete the tasks on a subsequent day and 3 were of middle SES. Thus, the bilingual group included 26 children (16 males, 10 females) bilingual in Greek and Albanian, with low SES.

In the monolingual group, 34 children were initially tested. The data from 10 children were excluded from the analysis because 8 were of a middle SES and 2 did not complete all the tasks. Thus, the monolingual group consisted of 24 children (6 males, 18 females) monolingual in Greek, who were matched on SES to the bilingual group. Mean age for the bilingual group was 9 years 3 months and for the monolinguals it was 9 years 4 months (see Table 3.1).

A self-report questionnaire (see Appendix E), designed to assess SES and linguistic background, was used to gain more detailed information on the participants' SES level and Language background (see Appendix G for the Language background of the participants). This, along with a short information sheet and a printed consent form were included in a research envelope and disseminated to all children of appropriate ages.

All children were recruited from two public schools in the center of Thessaloniki. When all research envelopes were collected, children who had provided the researcher with a signed parental consent form were arranged to be tested. In total, out of 203 children, 52 provided a signed consent form (see Appendix C). From these children, 15 were excluded due to advanced age (12 years old) and 8 could not be contacted as the parents did not write their own or their child's name on the consent form.

As an incentive, children participants were given 2 colourful pencils after completing the experimental tasks (one in the middle of the experimental procedure and one at the end). Additionally, they were informed that all their data will be compared to each other for speed and accuracy.

For a summary of participants' ages, SES level and mean scores on the two tests used to match participants on general intelligence and verbal ability, described below, see Table 3.1. Independent t-tests analyses of Age, SES level, Greek WISC Vocabulary scores and Raven's CPM scores, confirmed that the Language groups did not differ significantly in any of these variables. Thus, all participants were well matched for age, SES level, verbal ability and general intelligence.

Table 3.1. Summary of participants' ages, SES level, WISC Vocabulary and Raven's CPM raw scores in the monolingual (n= 24) and bilingual groups (n =26) in Experiment 2.

	Monolingual M (SD)	**Bilingual M (SD)**	***t*-values**
Age (in years)	9.43 (1.46) Min age 6 Max age 11	9.28 (1.57) Min age 7 Max age 11.5	$t(46)= .325, p> .05$
SES	5.27 (1.2) Min SES 3 Max SES 7	4.85 (1.1) Min SES 3 Max SES 7	$t(46)= 1.271, p> .05$
G-WISC Voc* A-WISC Voc*	25.44 (12.03)	19.88 (8.76) 21.38 (7.64)	$t(46)= 1.779, p> .05$
Raven's CPM	28.27 (6.27)	26.23 (5.92)	$t(46)= 1.160, p> .05$

*** G-WISC Voc. = raw scores on the Geek version of WISC Vocabulary subscale**
*** A-WISC Voc. = raw scores on the Albanian version of WISC Vocabulary subscale**
SES: 2 to 7= low SES, 8 to12= middle SES, ≤13= high SES

Material

Given that it is essential to match participants for general intelligence in bilingual studies (e.g. Colzato et al., 2008), we used the Raven's Coloured Progressive Matrices (CPM; Raven, Court & Raven, 1990) for children for this purpose and the expressive Vocabulary subtest of the Weschler Intelligence Scale for Children-version III (WISC-III; 1991) to match bilingual and monolingual children on verbal ability, in both Greek and Albanian (translated by a psychologist of Albanian origin with excellent command of the Greek language).

Demographics and Language background questionnaire

For a detailed description of monolinguals and bilinguals in SES level, Language Use & Language Skill, see Appendix G. Level of SES was recorded through the Demographics and Language Background questionnaire (see Appendix E). This measure was designed according to similar questionnaires used in previous studies on the cognitive effects of bilingualism (Abedi, Lord & Plummer, 1997; Brown, Bown & Eggett, 2009; Costa, Hernandez & Sebastian-Galles, 2008; Garrat & Kelly, 2008; Gullberg & Indefrey, 2003; Portocarrero et al., 2007). For bilingual parents, the questions were translated from Greek to Albanian by a native Albanian psychologist, proficient in Greek. According to Delgado et al. (1999), the ratings on such a questionnaire do not seem to be influenced by the language of the items included.

The parental educational level and occupational status were assessed, of both parents, as indicators of familial SES. The total scores from these sections were then divided by two, to obtain a mean final SES score. In detail, to assess SES, we asked each parent on his/her education level, type of occupation and specific position in that occupation. The total SES score of the respondent (2 to 7= low SES, 8 to12= middle SES, ≤13= high SES) was the sum of scores on one item on educational level and on three items on occupational status. Similarly, Type-of-Occupation (e.g. Natsiopoulou & Melissa-Halikiopoulou, 2009) and Education Level (e.g. Benetou et al., 2000) have been repeatedly used to measure SES of Greek participants (for a review see Economou & Nikolaou, 2005).

In addition, there was a section on the demographics of each child, including items on his/her age, gender and nationality. Moreover, there was a section on the language background of the participating child. In this section, we included items on the spoken languages, age of arrival of the child in Greece as well as age of exposure to Greek, the years (if any) of formal education in Greek and the context and frequency of use of the Greek (L2) language (from 0= never use L2 to 4= every day). Finally, we included four items assessing perceived language proficiency (i.e. asked parents to rate on a 5-point Likert scale the reading, writing, comprehension and pronunciation abilities of the child),as previous research has demonstrated the importance of assessing language proficiency in all these four modalities separately (for a review see Mindt et al., 2008).

Computerized tasks

Both the ANT Child and the Language-switching task were displayed on a 15-inch monitor of a laptop PC, using E-Prime 1.1 (2002) software. The experiments were created with the E-Prime 1.1 (2002) software and responses were recorded via the computer mouse (ANT task) or a voice key (Language Switching task).

The ANT (Child version)

A Child version of the ANT task was adopted from that used for adults (Rueda et al., 2004), and used to assess the three main attention functions. It was identical to the adult version of the ANT, with the only difference in the stimuli used. That is, instead of arrows as target and flankers, yellow fish were used (see Figure 3.1). Moreover, on response, auditory feedback was automatically provided (“whohooooo” for correct responses and a “beep” for incorrect ones).

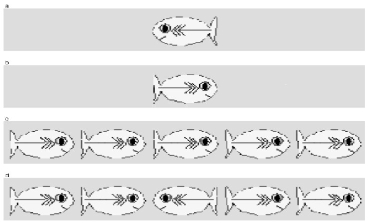

Fig. 3.1. Examples of the stimuli (flanker conditions) used in the ANT Child task, (a) the left-target neutral condition, (b) the right-target neutral condition, (c) the congruent flanker condition and (d) the incongruent flanker condition (figure adopted from Mezzacappa, 2004).

The child placed her/his two fingers on the mouse buttons (left and right). All children were verbally instructed that they had to feed the hungry fish that would be appearing on screen as soon as possible, by pushing either the left or the right mouse-button, according to the orientation of that fish. After that, the children were told that sometimes the fish would be appearing alone and sometimes it would be swimming with other fish; in such a case, they were told to focus on the central fish and press the button corresponding to that fish's orientation only, so as to feed it (for an example trial see Figure 3.2). Finally, all children were instructed to fixate at the central fixation point at all times.

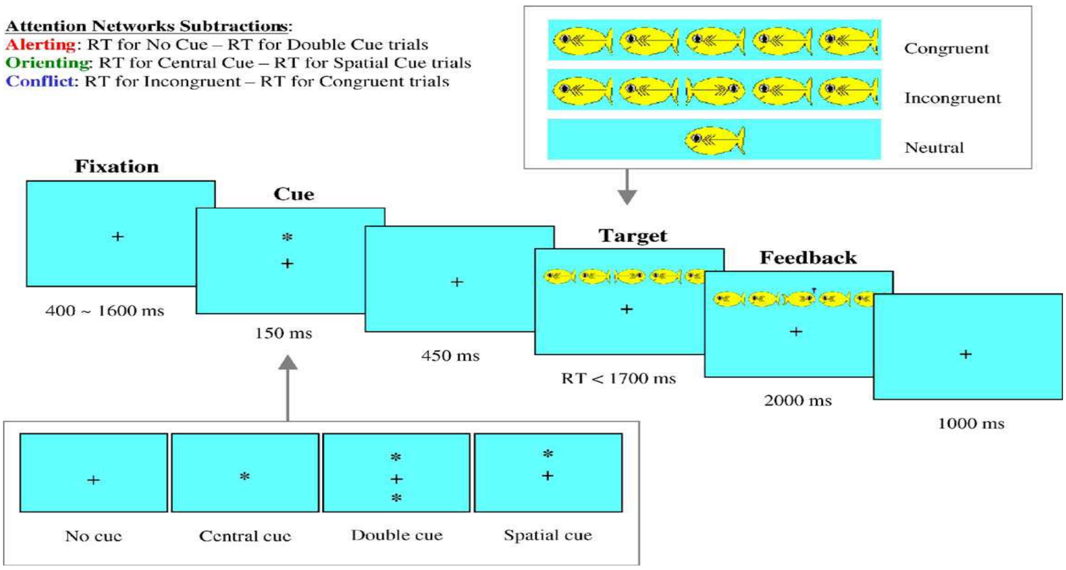

Fig. 3.2. Example trial and all cueing and flanker conditions of the ANT task, Child version (figure adopted from Rueda et al., 2004).

As soon as the participants showed clear understanding of the instructions, the practice trials began. The experimenter was present throughout the procedure, but gave feedback and encouraged the child only during the practice trials. The experiment included 24 practice trials, providing feedback to the participant, and three experimental blocks with 96 trials each without feedback. In total, 288 experimental trials were presented. Each trial was a combination of one of the 4 cueing conditions (central cue, alerting-sound cue, spatial cue, no cue) with one of the 3 flanker conditions (congruent, incongruent, neutral), and was presented 24 times (8 times in each block). Presentation order of trials was randomized.

The Language-switching task

Children were instructed to respond (i.e. read aloud the digit on the screen) in the language suggested by the language-cue (flag; see Figure 3.3). They were encouraged to respond as quickly and accurately as possible. A microphone, connected to a voice key, was used to respond to the target.

Fig. 3.3. Examples of the stimuli used as language-cues in the Language-switching task.

The design of this task was adapted for young children. Specifically, the experiment was divided in one short practice block of 18 trials and two longer experimental blocks of

36 trials each. Digits were presented in short sequences (“lists”) from 1 to 9, in a sequential manner. Four such lists were presented in each experimental block. Only switch trials (i.e. trials where the language of response, either L1 or L2, was different than the language used in the preceding trial) were included. In each block, half of the trials (18) required a response in L1 and the remaining half (18) in L2. Thus each language, either Greek or Albanian, was equally represented (36 trials in L1 and 36 trials in L2).

A welcoming message was initially displayed, followed by 2 training lists, after which the experiment began. Task duration was approximately 5 to 7 minutes. Each trial lasted until response to target and the next trial onset took place 400ms after response (triggering of voice-key).

Procedure

After the study was approved by the Greek Ministry of Education and Lifelong Learning, the principals of several public schools were informed of the study. Two schools agreed to participate. All teachers of those schools were informed about the study. After that a research envelope, including a small information sheet which did not reveal the exact aims of the study, a printed consent form sheet and the Demographics and Language Background questionnaire, was disseminated to all children. The teachers were kindly asked to remind the children to give it to their parents and then bring it back to the teacher.

Only children who returned the consent form signed by one parent and the Language Background questionnaire completed by one parent were tested. Each child was tested individually in a quiet classroom of his/her school, on a laptop PC.

The order of task administration was counterbalanced for all participants. For example, testing began with the intelligence and vocabulary measures (Raven's CPM; WISC-III Vocabulary test), followed by the computerized tasks were executed (language-switching as the measure of level of bilingualism; the ANT Child). For both these tasks, instructions were given orally by the experimenter and presented on the computer screen in written.

3.3. Results

The ANT Child task

The latencies and error rates of 26 bilingual and 24 monolingual children were analyzed. According to Fan et al. (2002) and Rueda et al. (2004), the Conflict effect, reflecting the executive attention function, was calculated by subtracting mean RT in congruent trials from mean RT in incongruent trials. To obtain the Alerting effect, reflecting the alerting attention function, mean RT in double-cue trials were subtracted from mean RT in no-cue trials. Finally, to calculate the Orienting effect, reflecting the orienting network of attention, we subtracted mean RT in spatial-cue trials (i.e. trials were the cue was either above or below fixation) from mean RT in central-cue trials.

Error analysis

A 3 x 4 x 2 mixed ANOVA was used to analyze mean accuracy scores, with Flanker type (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors and Language group (monolingual and bilingual) as the between-subjects factor. No main effects or interaction reached statistical significance. Thus the percentage of correct responses was comparable between the groups (monolinguals 98.31%, bilinguals 97.01%).

Response Times analysis

A 3 x 4 x 2 mixed ANOVA was used to analyze mean correct RTs, with Flanker type (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors and Language group (monolingual and bilingual) as the between-subjects factor (see Table 3.2). A significant main effect of Flanker type was indicated, [$F(2, 276) = 134.693$, $p < .00001$, $\eta^2 = .745$]. Bonferroni post-hoc tests indicated that RTs in the Incongruent condition (M= 750.58, SD= 159.83) were significantly slower than for the Congruent (M= 672.16, SD= 143.37) and Neutral (M= 646.66, SD= 137.62) conditions, $p < .00001$. Thus, a Conflict effect was revealed for all participants. In addition, RT for Congruent trials were significantly slower than for the neutral trials, $p < .00001$.

A main effect of Cue type was also evident, [$F(3, 276) = 76.797$, $p < .00001$, $\eta^2 = .625$]. According to Bonferroni post-hoc tests, RTs for the Spatial-cue trials (M= 651.56, SD= 143.48) were significantly faster than for the Central-cue trials (M= 695.58, SD= 154.72), $p < .00001$, thus indicating an Orienting effect. Additionally, RTs for the Double-cue trials (M= 668.93, SD= 139.45) were significantly faster than for the No-cue trials (M= 743.14, SD= 150.09), $p < .00001$, revealing the presence of an Alerting effect. The interaction between Flanker and Cue type did not reach significance.

Table 3.2. Means and (Standard Deviations) of RT in milliseconds for each Language group.

Flanker type	Language group	Cue type				
		No cue	Central cue	Double cue	Spatial cue	**Mean Flanker**
Congruent	Monolinguals	707.71 (143.32)	657.15 (151.79)	632.88 (159.18)	609.07 (157.69)	649.18 (137.12)
	Bilinguals	752.63 (152.80)	694.15 (143.97)	665.79 (120.10)	657.91 (119.13)	694.31 (121.24)
Incongruent	Monolinguals	764.22 (154.39)	727.07 (182.00)	708.85 (181.20)	688.10 (181.20)	722.44 (154.49)
	Bilinguals	818.73 (145.74)	785.79 (152.27)	757.83 (126.87)	754.07 (150.71)	774.42 (133.20)

Neutral	Monolinguals	699.83 (173.61)	642.12 (178.84)	609.33 (132.69)	659.16 (117.54)	625.26 (134.67)
	Bilinguals	715.71 (131.81)	667.20 (122.20)	638.88 (119.39)	631.03 (125.82)	659.69 (110.43)
Mean Cueing	Monolinguals	721.37 (142.99)	669.61 (152.75)	648.64 (139.50)	623.23 (136.87)	
	Bilinguals	763.85 (130.89)	715.94 (126.72)	681.86 (111.90)	674.88 (119.18)	

As many cognitive functions, especially executive processes, are still sensitive to changes during childhood (e.g. Carlson, 2003), and age range of our sample was rather broad from 6 to 11 years old, we further submitted the data to a 3 x 4 x 2 mixed ANCOVA with Flanker type (congruent, incongruent, neutral) and Cue type (double, no, central, spatial) as the within-subjects factors, Language group (monolingual and bilingual) as the between-subjects factor and Age as the covariate. The main effects of Cue, [$F(3, 270)= 3.032$, $p= .032$, $\eta^2= .063$] and Flanker, [$F(2, 270)= 15.042$, $p< .00001$, $\eta^2= .251$] were again significant after controlling for the effects of age, both following the same pattern mentioned above. Thus, a Conflict, an Alerting and an Orienting effect were evident for all participants, regardless of age.

Additionally, a significant interaction between Cue type and Flanker type was revealed, [$F(6, 270)= 3.035$, $p= .007$, $\eta^2= .063$], after controlling for the effect of Age. This interaction was further investigated using planned comparisons to compare RTs for Incongruent versus Congruent and for Incongruent versus Neutral Flanking conditions, both representing the Conflict effect (Fan et al., 2002), for each Cueing condition (central, double, no and spatial cueing).

This analysis showed that all participants resolved conflict faster when the alerting or orienting attention systems were not also engaged, as evident by the significantly smaller Conflict effect in the No-cueing condition, $p< .005$, compared to all other Cue-type conditions. Although this finding seems rather surprising, it fits well with previous evidence which argue for the mutual influence of the three main attention networks (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005; Fan et al., 2005). More specifically, according to Fan et al. (2005), no-cue trials are low in alertness hence elicit larger RTs. This longer time to respond facilitates conflict resolution, most likely by allowing more time for executive attention processes to control responses, hence the smaller Conflict effect observed in No-cue trials.

Notably, even after controlling for age, the Language group factor did not reach significance neither interacted with any of the other factors. As this contradicts previous findings, specifically regarding a “bilingual additive effect” on executive attention in children (e.g. Bialystok, 1999; Bialystok, 2010; Bialystok & Martin, 2004; Bialystok & Saphero, 2005; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008; Poulin-Dubois et al., 2011), we further analyzed the data for each attention network separately (see Table 3.3).

Table 3.3. Summary of performance of both Language groups in the ANT Child task (mean correct RT measured in milliseconds). The table is divided by the different conditions required to calculate performance in each main attention network.

	Monolinguals (N= 22)	Bilinguals (N= 26)
Flanker Condition	M (SD)	M (SD)
Incongruent	721.88 (167)	779.36 (137.28)
Congruent	651.47 (148.21)	692.35 (128.17)
Conflict Effect	**70.41***	**87.01***
	Monolinguals (N= 22)	Bilinguals (N= 26)
Cue Condition	M (SD)	M (SD)
No Cue	723.81 (153.31)	762.12 (137.75)
Double Cue	650.07 (151.23)	687.05 (115.5)
Alerting Effect	**73.74***	**75.07***
	Monolinguals (N= 22)	Bilinguals (N= 26)
Cue Condition	M (SD)	M (SD)
Central Cue	675.05 (165.06)	714.51 (133.04)
Spatial Cue	622.36 (148.54)	681.15 (124.57)
Orienting Effect	**52.69***	**33.36***

***** *sig. at* $p \leq 0.05$

Detailed assessment of the 3 attentional networks

(a) The executive network of attention (Conflict effect)

For the Conflict effect, we collapsed the data and calculated the conflict effect for each participant (RT Incongruent – RT Congruent), and conducted t-tests to compare the Bilinguals vs. Monolinguals. A non-significant tendency, $p > .05$, for bilinguals to show a larger conflict effect than the monolinguals was observed (see Figure 3.4).

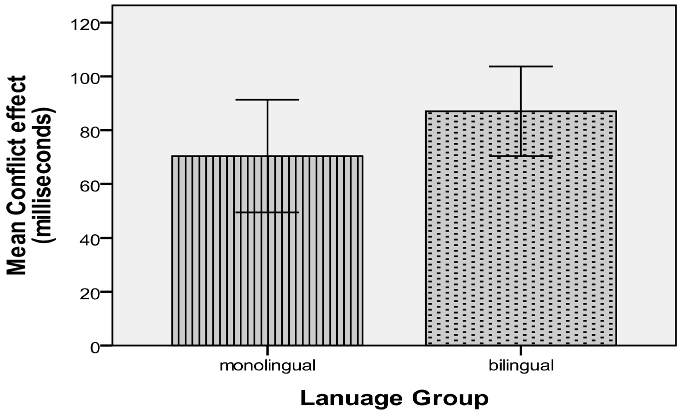

Fig. 3.4. The mean Conflict effect (RT for Incongruent – RT for Congruent trials) for bilinguals (N= 26) and monolinguals (N= 24). Bars represent SE.

(b) The alerting network of attention

Data were collapsed for Flanker type and the Alerting effect was calculated (RT No-cue – RT Double-cue). According to independent t-tests between the language groups, the Alerting function was not modulated by bilingualism (see Figure 3.5).

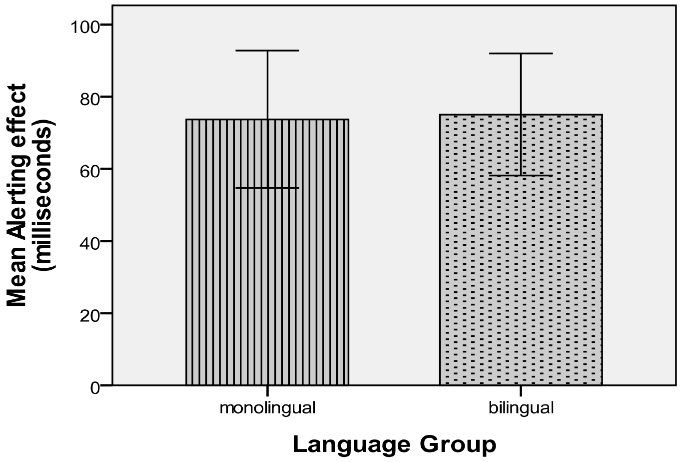

Fig. 3.5. The mean Alerting effect (RT for No-cue – RT for Double-cue trials) for bilinguals and monolinguals. Bars represent SE.

(c) The orienting network of attention

Data were collapsed for Flanker type and the Orienting effect (RT Central-cue – RT Spatial-cue) was calculated. Orienting was then compared between monolingual and bilingual children using an independent t-test. Bilingualism did not modulate the orienting attention function, as the orienting effect was similar for both bilinguals and monolinguals (see Figure 3.6).

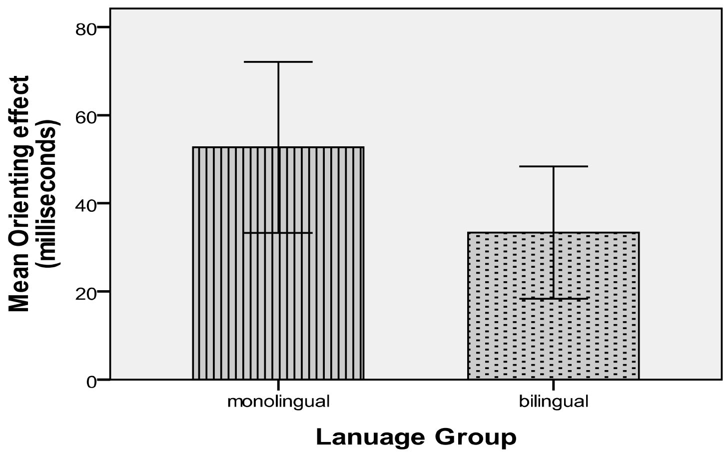

Fig. 3.6. The mean orienting effect (RT in Central-cue – RT in Spatial-cue trials) for monolinguals and bilinguals. Bars represent SE.

Language-switching task

Mean RTs in the Language-switching task were analyzed by paired t-tests, comparing response latencies to switch to L1 (Albanian) with response latencies to switch to L2 (Greek). Results showed that mean RTs to switch back to L1 (M= 1375.34, SD= 738.45) were significantly slower than those required to switch to L2 (M= 1078.56, SD= 454.11), $t(24)= 3.608$, $p= .001$.

As the standard deviations of the mean language-switching RTs were quite high, a square-root transformation was subsequently used to normalize the distribution of scores. These transformed data were again submitted to the same analysis, which showed the same pattern of results. That is, again mean RTs to switch back to L1 (M= 36.013, SD= 9.013) were significantly longer than to switch to L2 (M= 32.41, SD= 6.29), $t(24)= 3.765$, $p= .001$. Thus, an asymmetrical switch-cost was revealed from the analyses of both transformed and non-transformed data, likely indicating the existence of proactive inhibition when switching back to L1. This suggests that the bilingual children in this experiment were dominant bilinguals, contradicting the parental statements in the Language background questionnaire claiming that the children were balanced in using two languages.

Since the overall performance of the participants in the switching task suggests that our bilingual participants are not balanced, we conducted further analyses to investigate the relationship between cognitive performance and scores on bilingualism from the Language Switching task and the Language Background questionnaire. For example, it has been suggested that several characteristics of bilingualism, such as age of exposure in

L2, L2 skill, frequency of use of L2, may influence bilingual language-switching (Abultalebi & Green, 2008).

We subtracted mean RTs to switch to L2 from mean RTs to switch to L1, which provided us with a score of the switch-cost asymmetry (e.g., a score of 0 would mean that the participant is fully balanced). Out of 26 bilingual children, 16 responded slower when required to switch back to Albanian than to Greek, thus suggesting that these children had Albanian as L1, though the opposite was true for 10 children, thus implying that they had Greek as L1, from a cognitive perspective that is.

We then entered this Switch Cost Asymmetry variable (SCA) to a correlation analysis along with the Conflict, Alerting and Orienting effects provided by the ANT Child task. We expected that Switch Cost would positively correlate with the Conflict effect. As the standard deviations of the SCA variable were very high, we used a square root transformation in all data to normalize the distribution (see Table 3.4).

Table 3.4. Means and SDs for the original and transformed data included in the analyses of the Language Switching task.

	Non-transformed data M (SD)	Transformed data M (SD)
Switch Cost Asymmetry (SCA)	306.44 (389.60)	14.20 (10.45)
Conflict	87.01 (42.55)	9.10 (2.16)
Alerting	75.08 (43.05)	8.25 (2.70)
Orienting	33.36 (38.33)	10.04 (2.13)

The significance level was adjusted with the Bonferroni correction for multiple comparisons (alpha level= 0.013). Contrary to our prediction (see Table 3.5), the analysis did not yield any correlation between SCA and the Conflict effect. Moreover, although the Alerting and the Orienting effects were also not related to SCA, the analysis revealed an interesting relationship between two attention effects. Specifically, Alerting was related to the Orienting effect, $r(24) = .995$, $p < .00001$, thus further supporting a mutual influence between the attention processes reflected by these effects.

As highlighted earlier, age seems to be an important factor influencing the performance of children in cognitive tasks. Thus, we conducted the same correlation analysis by controlling for the Age variable. Interestingly, this revealed a marginally significant correlation between SC and Conflict, $r(23) = .425$, $p = .017$ (see Figure 3.7). The previous correlation among Alerting and Orienting remained identical after controlling for Age, $r(23) = .995$, $p < .00001$.

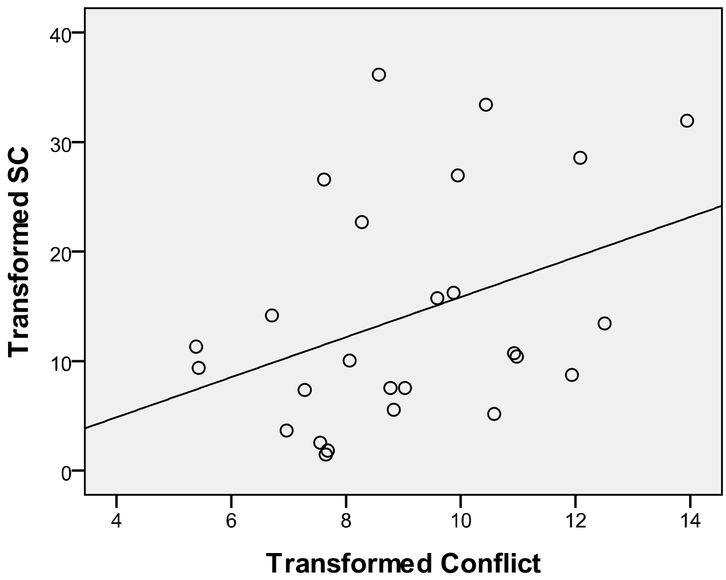

Fig. 3.7. The marginal correlation between Switch Cost (SC) and the Conflict effect, both reflecting the executive control of attention function, after controlling for Age.

As mentioned in the Introduction of this chapter, SES is an important non-linguistic factor which influences attention processes and especially executive attention, to the degree that it may account for the bilingual additive effect in attention found by previous studies that had not effectively controlled for this variable. For this reason, the same correlational analysis was again conducted, although now controlling for SES. This did not change the initial pattern of results, as the relationship between Alerting and Orienting remained the same, $r(23)= .995$, $p< .00001$. No other correlations reached statistical significance.

Table 3.5. Inter-correlations for measures of SCA, Conflict, Alerting and Orienting before and after partialling out Age and SES.

	Conflict	Alerting	Orienting	Age	SES
Switch Cost Asymmetry (SCA)	.378	.034	.035	-.004	.392
Conflict		.326	.301	-.415	.326
Alerting			.995*	-.068	.144
Orienting				-.047	.153
controlling for Age					
SCA	.425*	.035	.036		
Conflict		. 329	.311		
Alerting			.995**		
controlling for SES					
SCA	.287	-.024	-.028		
Conflict		.298	.269		
Alerting			.995**		

sig. at the 0.02 level
****sig. at the 0.01 level (Bonferroni correction for multiple comparisons)***

Finally, to reveal any possible relationships between various aspects of bilingualism (L2 Skill, L2 Frequency of Use, Age of Exposure in L2) with the SCA and/or the Conflict effect, we submitted these variables in a correlation analysis, with Bonferroni correction for multiple comparisons (alpha level= 0.01). Contrary to our expectations, the results (see Table 3.6) did not show any correlation between Frequency of L2 Use and

SCA or the Conflict effect. Also, Age of Exposure in L2 was not related to any of the other variables. However, as predicted, L2 Skill was negatively related to the Conflict effect, $r(24) = -.491$, $p = .011$. That is, the more skilled a bilingual is in L2, the easier it is for her to resolve conflicting information of a non-linguistic nature as the magnitude of the Conflict effect decreases. This supports and extends the findings of Segalowitz and Frenkiel-Fishman (2005) who showed that L2 skill is related and can also predict performance on an attention-shifting task.

This relationship between Conflict and L2 Skill did not change after controlling for the effects of Age or SES.

Table 3.6. Inter-correlations for measures of SCA, Conflict, Frequency of L2 Use, Age of Exposure in L2 and L2 Skill.

	Conflict	Frequency of L2 Use	Age of Exposure in L2	L2 Skill
SCA	.378	.053	.018	-.255
Conflict		.090	-.103	-.491**
Frequency of L2 Use			.042	-.025
Age of Exposure in L2				.020
controlling for Age				
SCA	.425	.050	.010	-.261
Conflict		.247	.161	-.476*
Frequency of L2 Use			-.145	-.074
Age of Exposure in L2				-.075
controlling for SES				
SCA	.278	-.140	.091	-.235
Conflict		-.060	-.053	-.487**

Frequency of L2 Use	.127	.021
Age of Exposure in L2		.003

sig. at the 0.02 level
****sig. at the 0.01 level (Bonferroni correction for multiple comparisons)***

3.4. Discussion

Our evidence partially confirmed our hypotheses. Specifically, and contrary to our predictions, there was no difference in conflict resolution (Incongruent vs Congruent trials) between bilingual and monolingual children of low SES. As expected though, bilingualism did not modulate the alerting and the orienting functions of attention. Another interesting finding of the present experiment was the interaction between the Cueing and the Flanker factors. A previous study with children using the ANT Child (Rueda et al., 2004) did not yield such an interaction, attributing it either to the sample size or to other factors such as size of display or visual angle. However, this interaction is in-line with the findings with young adults (Fan et al., 2002). That is, we found that the conflict effect was significantly smaller for the No-cueing condition, in relation to the other conditions with spatial or temporal cues. There may be two explanations for this interaction. When a cue is temporal or spatial, evidence suggests that the network in charge of attentional control is disconnected so that target detection is prioritized and maximized. This argument is supported by neuroimaging data showing an interaction (excitatory and inhibitory connections) between the attentional networks (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005, Hernández et al., 2010; Fuentes, Vivas, Langley, Chen, & Gonzales-Salinas, 2011). Specifically, when participants are in an alertness state studies have shown that the right frontal cortex (which is part of the alertness network) is activated while the anterior cingulated (which is part of the executive attention network) is deactivated. This could explain why when the target appears in the incongruent trials participants may take longer to resolve the conflict relative to a state of low alertness (no cue). Importantly, the present findings suggest that attentional networks interact in children similarly to adults.

The lack of a bilingualism effect on executive attention is in disagreement with previous studies that showed a bilingual advantage over monolinguals in tasks of attentional control (e.g. Bialystok, 2006; Bialystok & Craik, 2010; Bialystok et al., 2005; Bialystok et al., 2009; Bialystok & De Pape, 2009; Colzato et al., 2008; Costa, Hernández & Sebastian-Galles, 2008; Fernandes et al., 2007; Festman, Rodriguez-Fornells & Münte, 2010; Hernández et al., 2010; Kharkhurin, 2010; Poulin-Dubois et al., 2011). One of the main differences between all these previous studies and the current one is a careful control of SES. That is, in the majority of research on a bilingual effect on cognition, there is an SES- mismatch between the groups, or the participants are of middle or higher-SES, or SES has not been measured at all (Morton & Harper, 2007). In fact, it has been assumed in several of these studies that bilingual and monolingual children had the same SES because they were recruited from the same schools and/or lived in the same neighborhoods (Bialystok, 2009). This argument was clearly disconfirmed in our study, since we had to exclude 11 participants that had a higher SES than the sample included in the study although they were recruited from the same school and lived in the same neighborhoods. This stresses the need to carefully measure and control for SES in studies investigating the bilingual effects in cognition. We suggest that the bilingual advantage in previous studies has probably been exaggerated by a confound effect of SES on cognitive function (for a review see Magnuson & Duncan, 2006; Mezzacappa, 2004; Morton and Harper, 2007).

Another potential explanation for the lack of effect of bilingualism could be that our sample of bilinguals did not consist of balanced bilinguals as shown by the Language Switching task. It is important to notice that the finding of the Language Switching task was not in agreement with the self-report measure (in this case parental report) which is the only measure used so far in studies of bilingualism to assess proficiency in language 2.

In order to address the research question of how much experience in bilingualism may be needed for a benefit effect on cognition, we conducted correlation analyses between the SCA and the effects from the ANT task and found a significant positive correlation between SCA and the magnitude of the Conflict effect, when controlled for the age factor. So although we did not find an effect of bilingualism when comparing monolinguals and bilinguals, and although our bilinguals were not balanced, the correlation suggests that there is a relationship between dominance of the first language (how strongly activated both languages are) and the ability to resolve the conflict.

To further specify the mechanisms underlying the bilingual influence in cognition, we additionally assumed that if a relationship emerged between the conflict bilinguals experience in resolving incongruent information and another characteristic of bilingualism, such as L2 skill (i.e. how well one reads, writes, comprehends and speaks in L2), which is not directly related to inhibition, this could suggest that it is not inhibition *per sé* that is trained by the bilingual experience, as it is difficult to conceive a link between inhibition of irrelevant information and L2 skill, but maybe it is the fact of being bilingual in more general that trains and hence improves one's executive attention ability. Thus, we predicted L2 skill to be negatively related to the Conflict effect, indicating that the more skilled one is in a second language, somehow influences her executive attention ability. This was confirmed by our results, with higher proficiency in L2 being related to faster resolution of conflict.

These findings agree with previous claims regarding a main executive control mechanism responsible for all tasks requiring cognitive control, which seem to be trained not only by the bilingual experience of lifelong language-switching (e.g. Bialystok, 1999; Bialystok, 2010; Bialystok & Martin, 2004; Bialystok & Shapero, 2005; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008; Poulin-Dubois et al., 2011), but more generally by becoming skilled in a second language which involves more general executive functions (Segalowitz & Frenkiel-Fishman, 2005), hence the relationships of SCA and of L2 Skill with conflict resolution.

To sum up, in this study we have shown that eliminating the confound effect of SES may attenuate the so-called "bilingual effect" in all the three main attention functions in children. However, this by no means suggests that bilingualism does not have any effect on attention processes. This is further supported by the positive correlation between SCA and the magnitude of the conflict effect, and the negative relationship between L2 Skill and Conflict. These two relationships suggest that the more balanced a bilingual is (the more experienced in switching between the two languages and generally the more skilled in L2), the faster she/he is in resolving conflicting information.

To conclusively determine whether bilingualism modulates attention or not, we suggest using a larger sample of again low SES individuals, however with attention tasks that are more linguistic in nature and that tap more general executive attention processes. This will offer a more thorough investigation of how bilingualism may influence the mechanisms of attentional control in the developing and the developed mind of a bilingual individual.

Experiment 2

Attentional processes and pragmatic competence of young children bilingual in Albanian and Greek, of a low socioeconomic status.

3.5 Introduction

Experiment 1 found no bilingual benefit over monolinguals when the effects of SES on cognition are carefully controlled for. However, this clearly goes against the results of numerous other studies on the cognitive effects of bilingualism (e.g. Bialystok, 1999; Bialystok, 2010; Bialystok & Martin, 2004; Bialystok & Shapero, 2005; Carlson & Meltzoff, 2008; Costa, Hernández & Sebastián-Gallés 2008; Hernández et al., 2010; Martin-Rhee & Bialystok, 2008; Poulin-Dubois et al., 2011). Furthermore, according to Bialystok (2009), there remains the possibility that the effects of SES and bilingualism are independent. For these reasons, further examination of a possible bilingual effect on attention is warranted. Moreover, the results of experiment 1 indicated that there may be cognitive effects of bilingualism, however less salient than expected and may exert an influence not in control of attention solely, but in more general executive functions as well.

To test this hypothesis, in the present experiment we included a task of a linguistic nature which involves more general executive control abilities and mainly shifting attention between linguistic representations and WM and hence resembles the bilingual experience of language switching: The Scalar-Implicature task (SI), described in detail below. In order to respond correctly in the SI task, one must flexibly shift attention from the semantic to the pragmatic meaning of a sentence (Katsos & Bishop, 2011) and simultaneously hold in mind the stronger, alternative scalar term of the scale used in that sentence, hence the WM demands put in this task (De Neys & Schaeken, 2007). In turn, cognitive flexibility ability has been shown to share common neural substrates with executive control of attention and specifically the ability to perceptually inhibit distractors (Armbruster, Ueltzhöffer, Basten & Fiebach, 2012). Thus, we believe that the SI task is a suitable linguistic task to assess the –possibly- advanced inhibition ability of bilinguals.

Scalar implicatures constitute the best-known type of pragmatic inference (Papafragou & Musolino, 2003). A comprehensive framework of pragmatic inference was firstly proposed by Grice (1989). According to Grice, for a linguistic message to be correctly understood, the listener must derive the inferential along with the literal meaning of that message. For the implicit information of that message to be effectively communicated, a conversation must be a cooperative process governed by four Maxims, or pragmatic rules. That is, the message of the speaker must be (a) sincere (maxim of *Quality*), (b) informative (maxim of *Quantity*), (c) relevant to the conversation's topic (maxim of *Relevance*) and (d) phrased in an appropriate manner (maxim of *Manner*). By following these rules, the possible inferences that can be drawn from the message are narrowed down to the most logical and hence correct ones. Violating any one of these maxims may create a variety of linguistic effects, such as SI (Geurts, 2010).

An example of SI by violating the Gricean Maxim of *Quantity* is the following: Consider the phrase *"Some cats are black"*. This violates the maxim of *Quantity*, or informativeness, as the speaker, instead of wording the whole message, used a weak item (*some*) of a set of ordered alternatives (*some; most; all*), called a scale, to imply that the strongest item of that scale is not true (*all;* Siegal, Matsuo & Pond, 2007), hence the term Scalar Implicatures. Given that the speaker has followed the maxims, thus her message was phrased appropriately and included sincere information, the listener holds that the weaker term *some* was used because the speaker did not have enough information to sincerely claim the strongest *all*. Thus, *all* does not hold for this statement, or in other words the message perceived is *"Not all cats are black"*.

Very few studies have investigated bilingualism's influence on SI. However, those studies have showed that bilingual children outperform monolinguals in SI tasks (Siegal, Matsuo & Pond, 2007; Slabakova, 2009). The limited number of studies looking at the influences of bilingualism in pragmatic competence in more general (i.e. violation of Grecian maxims, not just SI; Siegal, Surian, Matsuo, Geraci, Iozzi, Okumura et al., 2010; Siegal, Iozii & Surian, 2009; Surian, Tedodli & Siegal, 2010) have also pointed to a bilingual advantage. However, none of the above studies have sufficiently controlled for the confound of SES, by either matching their participants for SES level or including low-SES individuals or –ideally- both.

In addition, we aimed at narrowing the age range to 6-7 year olds in this Experiment. Rueda and colleagues have shown that the attentional networks develop until at least the age of 7 years old (Rueda, Rothbart, Maccandliss, Saccomanno & Posner, 2005), and in Experiment 1 we found that the relationship between SCA and conflict emerged only when we controlled for age. So we wanted to further investigate the effect of bilingualism on attention by eliminating the fluctuation in performance with age. Finally, in younger ages the bilingual effect in attention may be more evident since it is around this time where children make a change in the developmental course of attention as developmental research on monolinguals suggests (Guasti et al., 2005) and thus bilingual children may be ahead of monolingual children.

Based on the findings from Experiment 1, we expect the performance of bilingual and monolingual children to be similar in the ANT task. However, we expect that the bilingual children will outperform monolingual children in the SI task, although this effect may be weakened in our sample since the participants are matched for SES, hence limiting any SES influences to the minimum. Finally, we expect the switch-cost asymmetry to be related to the children's ability to resolve conflict in the ANT, to their L2 Skill and to the bilingual children's pragmatic competence.

3.6 Method

Participants

Inclusion criteria were identical to Experiment 1, except from the age range which was reduced to 6 until 8 years of age. All children were recruited from 3 public schools in the outskirts of Xanthi, a provincial town in northern Greece. After the study was approved by the Greek Ministry of Education and Lifelong Learning, the directors of the aforementioned schools were contacted, who were informed about the study by the researcher in person. A research envelope was then disseminated to all children of the ages of interest, including a small information sheet which did not reveal the exact aims of the study, a consent form sheet (see Appendix C) and the Demographics and Language background questionnaire (see Appendix E). The teachers were kindly asked to remind the children to give it to their parents and then bring it back to the teacher.

When all research envelopes were collected, children who had provided the researcher with a signed parental consent form were arranged to be tested. As an incentive, child participants were given 1 colorful pencil and 1 pen after completing the experimental tasks (one in the middle of the experimental procedure and one at the end). In total, out of 97 children, 88 provided a signed consent form and were initially screened, out of which 60 were included in the analysis.

For the monolingual group, 50 monolingual children were initially tested. Two were excluded because they did not wish to complete all the tasks and 16 were excluded because they came from middle to high SES family backgrounds. Thus, 32 children were finally included in the monolingual group (14 boys, 15 girls); they all were monolingual in Greek and of a low SES family background (see Table 3.7).

In the bilingual group, out of the 38 children who were initially screened, 5 were excluded because they could not count in Greek, one because she could not count in Albanian and 4 because they came from extremely low SES family backgrounds (e.g. complete absence of parental education), which did not match the characteristics of the rest of the sample. Thus, 28 children were finally included in the bilingual group (13 boys, 15 girls); they all were bilingual in Greek and Albanian and of a low SES (see Table 1for demographic data, and data on general intelligence and verbal ability).

Table 3.7. Summary of participants' ages, SES level, WISC Vocabulary raw scores and Raven's CPM raw scores and differences between the monolingual (n= 32) and bilingual groups (n =28) in Experiment 3.

	Monolingual M (SD)	**Bilingual M (SD)**	***t*-values**
Age (in years)	6.44 (0.82) Min age 6 Max age 7.7	6.77 (0.56) Min age 6 Max age 7.8	*t*(58)= 1.773, *p*> .05
SES	3.09 (0.52) Min SES 2 Max SES 4	2.89 (0.67) Min SES 2 Max SES 4	*t*(58)= 1.309, *p*> .05
Mean Parental Years of Education	9.05 (1.81)	8.36 (2.02)	*t*(58)= 1.397, *p*> .05
G-WISC Voc. raw scores	11.13 (4.93)	10.75 (5.41)	*t*(58)= 0.281, *p*> .05
A-WISC Voc. raw scores		11.57 (4.06)	paired-comparison with WISC VocGR scores of monolinguals: *t*(27)= 1.630, *p*> .05
Raven's CPM raw scores	20.13 (6.38)	20.00 (4.64)	*t*(58)= 0.086, *p*> .05

*** G-WISC Voc. = raw scores on the Geek version of WISC expressive Vocabulary subscale**
*** A-WISC Voc. = raw scores on the Albanian version of WISC expressive Vocabulary subscale**
SES: 2 to 7= low SES, 8 to12= middle SES, ≤13= high SES

As shown in Table 3.7 above, according to independent t-tests between the language groups, children in both groups were well matched for age, SES, expressive vocabulary and general intelligence. As Parental Years of Education has been suggested to be a leading factor within the SES construct (Davis-Kean, 2005), influencing children's cognitive abilities especially in low-SES environments (Rowe, Jacobson & van den Oord, 1999), we further investigated whether bilingual and monolingual children differed in mean Parental Years of Education. According to an independent t-test, both groups were well matched on this variable as well (see Table 3.7).

Information on the language background of the participants of both groups were recorded with the Language Background questionnaire. Bilingual children, as opposed to their monolingual counterparts, were skilled in a second language, exposed to an L2 early on and generally differed widely in all the other L2 characteristics from the monolinguals (see Appendix H).

Material and Procedure

The experimental procedure was identical to Experiment 1, with the addition of the SI task.

Demographics and Language background questionnaire

This measure was identical to that used in Experiment 1.

The Language-switching task

This task was identical to Experiment 1.

The Scalar Implicatures task

A version of Papafragou and Musolino (2003) SI task was used, which has been shown to be appropriate for measuring pragmatic competency of Greek children. Unfortunately, due to the experiemnter's lack of knowledge of the Albanian language, the task was administered only in Greek. Two types of scales were used: (a) a scale with terms of quantity (i.e. *all, some*; in Greek *ola, merika)* and (b) a scale with initiation/finalization terms (i.e. *start, finish;* in Greek *arxise, teliose*). Thus, the children were tested on how they interpret two types of scalar terms: *some, start*. These terms were presented in the following sentences:

(1) *Some* of the horses jumped over the fence

(2) The girl *started* making the puzzle.

However, the actual videotaped stories that were presented were truthfully described by the stronger term of each scale:

(3) *All* of the horses jumped over the fence

(4) The girl *finished* making the puzzle.

For example, in the story for sentence (1), actually all horses managed to jump over the fence. Thus sentence (1), although partially true, is pragmatically infelicitous for describing that story, as it implies that not all horses jumped over the fence. Instead, sentence (3) should have been used. If a child correctly interprets this implicature then, she/he should respond that (1) was not a good answer for describing the corresponding story and add, when asked, that expression (3) should have been used instead. The same logic underlies the other statement. Thus, we expected that if a child was sensitive to the scalar implicatures used in statements (1) and (2), she/he would respond that all these statements are not a good way to describe the stories where (3) and (4) are depicted.

A hand puppet ("Mr. Frog"), manipulated by the experimenter, was introduced to the child. The training phase was as follows: The puppet was presented with a toy tree. The experimenter then asked the puppet "What is this Mr. Frog?" and the puppet replied "It is a tree". Then, the experimenter asked the child "Did Mr. Frog reply well?" After that, the puppet was shown a toy pig and when asked, it replied "It is a dog". If the child could not provide a correct response when asked, the experimenter said "Mr. Frog did not say that very well. This is a pig". These training scenarios were used to ensure that children would critically consider the puppet's statements to decide whether what it said was true or not, instead of assuming that everything Mr. Frog says was only true or false.

After that, the testing phase begun. Children were presented with video-taped scenarios, whereby the puppet Mr. Frog was watching toys completing a task (see Table 3.8). The procedure followed was identical to the training phase, with the exceptions that the stories were played on the video and that no feedback was given on the child's responses for the test trials. The experimenter said "Now, shall we watch some stories and see whether Mr. Frog replies well?". The video was then played, showing one of the stories described in Table 2. After the completion of 1 depicted task, the video was stopped and the experimenter asked Mr. Frog what he thought happened in that story. The puppet answered using the terms described in Table 2 and the children were then asked whether he replied well. Scores of correct responses were 0 (wrong reply) or 1 (correct reply) and were manually recorded by the experimenter. Also, in case the child replied that the puppet did not reply well, the alternative answer he/she provided as a "good" answer was manually recorded by the experimenter.

Table 3.8. Test trials: Description of stories depicted in the video for the SI task and Puppet's statements that the children will be asked to judge.

Scalar terms	Story showed on video	Puppet's statements
{*all, some*} {*ola, merika*}	All horses jumped over the log.	Some horses jumped over the log.
	All rabbits went in the house.	Some rabbits went in the house.
	All dinosaurs ate trees.	Some dinosaurs ate trees.
	All playmobils bought dogs.	Some playmobils bought dogs.
{*start, finish*} {*arxise, teliose*}	The tiger finished painting the balloons.	The tiger started painting the balloons.
	The tiger finished putting the cars into the bag.	The tiger started putting the cars into the bag.
	The little girl finished making the puzzle.	The little girl started making the puzzle.
	The little girl finished eating her food.	The little girl started eating her food.

As can be clearly seen from Table 3.9, all test trials were designed to elicit a “No” response from the child. Thus, in order to balance out “Yes” and “No” responses, as well as to ensure that the child could correctly accept or reject the puppet’s statements, especially when these statements were accurate descriptions of the story depicted (thus eliciting a “Yes” response), control trials were also included in the task (see Table 3.9). Each control trial was presented after each test trial (in the order described in Tables 3.8 and 3.9).

Table 3.9. Control trials: Description of videotaped stories along with the analogous puppet’s statements.

<u>Scalar terms</u>	<u>Story depicted</u>	<u>Puppet’s statements</u>
{*all, some*}	The tiger bought <u>some</u> of the balloons.	The tiger bought <u>some</u> balloons.
	The strong man lifted <u>some</u> of the bags.	The strong man lifted <u>some</u> bags.
	Donald found some of the animals.	Donald found <u>some</u> animals.
	Donald played with <u>some</u> of the cars.	Donald played with <u>some</u> cars.
{*start, finish*}	Donald <u>started</u> putting the pens into the pencil-case.	Donald <u>started</u> putting the pens into the pencil-case.
	Donald <u>started</u> cleaning the table.	Donald <u>started</u> cleaning the table.
	The little girl started painting the picture.	The little girl started painting the picture.
	The little girl <u>started</u> drinking water.	The little girl <u>started</u> drinking water.

The ANT Child task

This task was the same as in Experiment 1, with the difference that instead of a double asterisk, we included an auditory high-frequency tone of a short duration as the Alerting cue. This change was made to enable more independent assessment of the three attention networks (Callejas, Lupiáñez & Tudela, 2004). That is, previously we used the same variable (i.e. an asterisk) manipulated differently to assess the Orienting (i.e. an asterisk presented to the subsequent target location) and the Alerting networks (i.e. a double asterisk presented above and below fixation). However, as the Alerting and Orienting attention functions in our previous experiment were correlated, we wanted to measure the possible mutual influence of these attentional effects more reliably in the present study, hence used an auditory Alerting cue, following Callejas, Lupiáñez and Tudela (2004).

3.7 Results

The ANT Child task

Error analysis

A 3 x 4 x 2 mixed ANOVA was used to analyze mean accuracy scores, with Flanker type (congruent, incongruent, neutral) and Cue type (alerting-cue, no, central, spatial) as the within-subjects factors and Language group (monolingual and bilingual) as the between-subjects factor. There was a significant main effect of flanker [$F(2, 116)= 17.335$, $p< .0001$, $\eta^2= .230$]. Post-hoc Bonferroni showed that accuracy in the Incongruent condition (M= 0.91, SD= 0.13) was significantly lower than in the Congruent (M= 0.96, SD= 0.08), and the Neutral flanker conditions (M= 0.96, SD= 0.07), *ps*< .0001. However, there was no significant difference between the congruent and the neutral condition. There was also a significant main effect of cue type, [$F(3, 174)= 3.196$, $p= .025$, $\eta^2= .052$]. According to a Bonferroni post-hoc comparison, there was a borderline effect of accuracy for the alerting-cue trials (M= 0.950, SD= 0.09) to be higher than the central-cue trials (M= 0.929, SD= 0.29), $p= .054$. The main effect of Language group was not significant, neither interacted with any of the other factors. Thus the percentage of correct responses was comparable between the groups (monolinguals 93.86%, bilinguals 94.21%).

Response Times analysis

A 3 x 4 x 2 mixed ANOVA was used to analyze mean correct RTs, with Flanker (congruent, incongruent, neutral) and Cue (alerting, no, central, spatial) as the within-subjects factors and Language group (monolingual and bilingual) as the between-subjects factor (see Table 3.10). There was a significant main effect of Flanker, [$F(2, 116)= 121.180$, $p< .00001$, $\eta^2= .676$]. According to Bonferroni post-hoc comparisons, RTs in the Incongruent condition (M= 899.195, SD= 144.71) were significantly slower than for the Congruent (M= 808.405, SD= 144.87), and Neutral (M= 778.37, SD= 139.50) conditions, *ps*< .00001. Also, RTs for Congruent trials were significantly slower than for the neutral trials, $p< .0001$.

The main effect of Cue type was also significant, [$F(3, 174)= 38.216$, $p< .0001$, $\eta^2= .397$]. According to Bonferroni post-hoc tests, RTs for the Central-cue trials (M= 832.607, SD= 147.28) were significantly faster than for the No-cue trials (M= 874.62, SD= 134.92), $p< .00001$. Additionally, RTs for the Central-cue trials were significantly slower than for the Spatial-cue trials (M= 791.93, SD= 147.69), $p< .0001$, revealing the presence of an Orienting effect. Also, RTs for the Alerting-cue trials (M= 815.47, SD= 143.78) were significantly faster than for the No-cue trials, $p< .0001$, thus indicating an Alerting effect. However, it took significantly longer for participants to respond in Alerting-cue compared to Spatial-cue trials, $p= .050$. Finally, RTs for the No-cue trials were significantly slower compared to RTs for the Spatial-cue trials, $p< .0001$.

Table 3.10. Means and (Standard Deviations) of RT in milliseconds as a function of Flanker and Cue condition for each language group.

Flanker type	**Language group**	**Cue type**				
		No cue	**Central cue**	**Alerting cue**	**Spatial cue**	**Mean Flanker**
Congruent	Monolinguals	868.26	830.05	806.97	770.43	818.93

		(158.60)	(164.02)	(165.45)	(193.86)	(153.45)
	Bilinguals	855.23	786.90	790.76	758.64	797.88
		(137.28)	(139.97)	(145.83)	(160.78)	(136.32)
Incongruent	Monolinguals	937.46	908.48	909.64	878.03	908.40
		(144.13)	(156.85)	(162.53)	(159.57)	(145.96)
	Bilinguals	920.57	898.02	887.81	853.54	889.99
		(138.49)	(165.17)	(151.24)	(159.44)	(145.29)
Neutral	Monolinguals	845.36	795.73	746.83	766.52	788.61
		(156.18)	(164.01)	(151.35)	(167.73)	(152.33)
	Bilinguals	820.88	776.46	750.80	724.40	768.14
		(126.34)	(145.11)	(130.20)	(142.05)	(125.11)
Mean Cueing	Monolinguals	883.69	844.75	821.15	804.99	
		(143.74)	(154.04)	(154.84)	(152.37)	
	Bilinguals	865.56	820.46	809.79	778.86	
		(125.99)	(140.83)	(132.57)	(143.63)	

There was also a significant interaction between Cue and Flanker, [$F(6, 348)= 2.555$, $p= .020$, $\eta^2= .042$]. To further investigate this interaction, the Scheffe post-hoc was used to compare RTs for Incongruent versus Congruent and for Incongruent versus Neutral Flanking conditions, both representing the Conflict effect (Fan et al., 2002), in each Cueing condition (central, alerting, no and spatial cueing). Results showed that, similar to Experiment 1, conflict was resolved faster when neither the alerting nor the orienting systems were involved, as evident by the smaller magnitude of the conflict effect in the No-cueing compared to the conflict in all other cueing conditions, $p< .05$. This further supports the inter-communication between the three main attention networks previously proposed (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005; Fan et al., 2005).

Detailed assessment of the 3 attentional networks

Each Network score (conflict, alerting, and orienting) was submitted to an independent t-test analysis. Similar to our previous experiment, results showed no significant differences between the Language groups for any of these effects (see Figure 3.8).

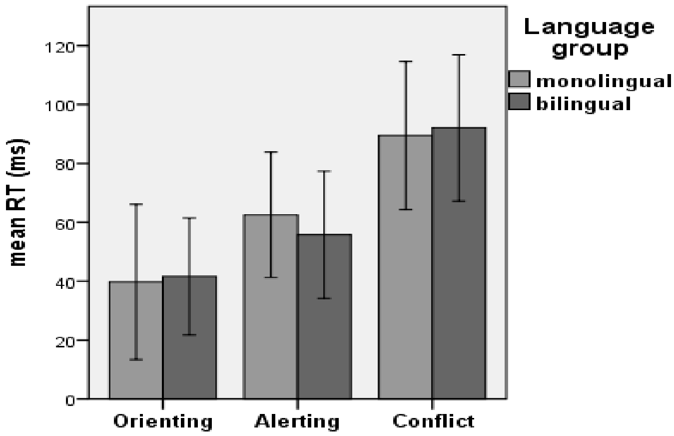

Fig. 3.8. The attention effects, reflecting the three main attention networks, did not differ between the Language groups. Bars represent SE.

The Scalar Implicatures (SI) task

To analyze the Scalar Implicatures task, we followed the procedure reported by Siegal, Matsuo and Pond (2007) who also tested the bilingual effect on a version of the SI task first designed by Papafragou and Musolino (2003). The number of correct responses in the test trials of the SI task was the dependent variable (i.e. number of "No" responses of the child when asked if the puppet described the video-taped situation well). The planned t-tests analyses did not show any significant difference between bilinguals and monolinguals in the SI task, *ps*> .05 (see Table 3.11). We also asked whether the correct responses between bilinguals and monolinguals differed in each scale (*all-some* and *start-finish),* and hence conducted a 2 (scale type) by 2 (language group) mixed ANOVA (see Table 3.16). There was a significant main effect of scale type, [$F(1, 56)= 14.966$, $p< .00001$, $\eta^2= .211$]. According to Bonferroni post-hoc comparisons, it was more difficult for all children to respond correctly to the *start-finish* than to the *all-some* scale, $p<.00001$. There was neither a main effect nor an interaction involving the Language group.

In order to ensure that when a child gave a correct "no" response in the SI task, he/she was actually shifting attention to the opposite scalar term that should have been used (e.g. *"all"* instead of *"some"*), and following the procedure of Papafragou and Musolino (2003), children were also asked to provide justifications for their negative answers. These were recorded during the task. Justifications were then separated in two categories: (a) correct ones, invoking the stronger scalar term (e.g. "that *all* of the horses jumped over the fence") and (b) irrelevant ones, where the child gave a justification not related to SI for his/her negative answer (e.g. "that *three* horses jumped over the fence"). We then compared the number of correct justifications between the language groups. Again, the analysis showed no significant differences between monolingual and bilingual children (see Table 3.11).

Table 3.11. Summary of performance of both Language groups in the SI task.

Score	Group	M (SD)	*p*-value
correct response	monolinguals	6.69 (4.53)	.342
	bilinguals	5.54 (4.77)	
correct resp. Some/All	monolinguals	3.87 (2.53)	.641
	bilinguals	3.15 (2.61)	
correct resp. Start/Finish	monolinguals	2.58 (2.25)	.940
	bilinguals	2.30 (2.76)	
correct justification	monolinguals	1.48 (2.10)	.734
	bilinguals	1.30 (2.07)	

The Language-switching task

Mean correct RT of all 28 bilingual children in the Language-switching (LS) task were analyzed by paired t-tests, comparing response latencies to switch to L1 (Albanian) with response latencies to switch to L2 (Greek). The analysis yielded an asymmetrical switch-cost, with RT to switch back to Albanian (M= 1982.90, SD= 999.94) being significantly longer than RT to switch back to Greek (M= 1524.66, SD= 726.52), $t(27)= 2.657$, $p= .013$. This indicates that our bilingual participants were dominant in L1, despite the parental self-reports stating an equal amount of use of the two languages in the children's daily lives (see Table 2 *"L2 frequency of use")*.

To further test for a relationship between bilingual skill and cognitive performance, we conducted Pearson correlation with Age and SES which were then partialled out, the SCA scores and the Attentional Networks scores, and correct responses in SI. The level of significance was adjusted according to the Bonferroni correction, to control for multiple comparisons. SCA was negatively related to Age [$r(27)= -.505$, $p= .007$], such that the younger the child, the larger the asymmetrical switch-cost. The SCA was significantly correlated with Conflict only after we controlled for SES [$r(27)= .466$, $p= .014$]. However, when we controlled for Age, this relationship disappeared, $r(25)= .355$, $p= .081$. Results are shown in Table 3.12 below.

Table 3.12. Inter-correlations for measures of Switch Cost, Conflict, Alerting, Orienting, SI correct responses, SES and age.

	Conflict	Alerting	Orienting	SI correct responses	SES	Age
SCA	.466	-.128	-.064	-.103	-.014	-.505**
Conflict		-.141	-.027	.225	-.142	-.360
Alerting			.026	-.182	.072	.211
Orienting				.254	.111	.420
SES						.217
			controlling for SES			
SCA	.467*	-.119	-.094	-.111		
Conflict		-.078	-.088	.163		
Alerting			.112	-.132		
Orienting				.208		
			controlling for Age			
SCA	.355	-.012	.169	-.019		

Conflict	-.003	.075	.248
Alerting		.022	-.179
Orienting			.144

**** significant at the 0.01 level (Bonferroni correction)***

Finally, we entered the data from the Language Background questionnaire (Age of L2 acquisition, Frequency of L2 Use, L2 Skill) along with the SI scores and the three attention effects from the ANT Child into a correlation analysis. Results showed no significant relationships between these variables, even when we controlled for Age or SES.

3.8 Discussion

Our previous experiment found no effects of bilingualism in attention. Importantly we matched the groups for low-SES, a confound factor that has been neglected in most studies on bilingualism. In this experiment we included younger children, whose cognitive capacities are still developing, since in our previous study we included a rather wide age range, and there had been qualitative differences in their attentional function. In addition, we included a task more relevant to the nature of bilingual language-switching.

Interestingly, the pattern of results from experiment 1 was repeated: The performance of bilinguals and monolinguals in the ANT Child, assessing the three main attention functions, did not differ, thus again suggesting that SES possibly attenuated the “bilingual effect” in attention over monolinguals, in agreement with Morton and Harper (2007). Most important, and contrary to our expectations, bilingual and monolingual children did not differ in the SI task. That is, in our study we did not find a bilingual effect on pragmatic competence, which is in contradiction with two previous studies that reported bilingual additive effect in drawing scalar implicatures (see Siegal, Matsuo & Pond, 2007 for developmental evidence; see Slabakova, 2010 for evidence with adult L2 learners).

As in Experiment 1, we also found a significant correlation between the SCA and the magnitude of the conflict effect but only when we controlled for the influence of SES. This suggests that the mechanisms used to control language switching and executive attention are at least partly common, though other sociocultural factors such as those reflected by SES may also play a role.

Contrary to our previous results in Experiment 1 and those of previous studies (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005), the analysis did not yield any relationships between the three attention networks. However, this finding is consistent with work by Posner and Boies (1971), Posner and Petersen (1990) and Fan et al. (2005), who argue for the anatomical and functional independence of the three attention networks. It may be that, due to their young age, the children involved in this experiment recruited different neural mechanisms to provide the required responses than the ones involved in Experiment 1, as is the case when comparing children and adults (Bunge, Dudukovic, Thomason et al., 2002), which could explain the null relationships between the three attention networks reported now. This may also explain why when we controlled for the influence of Age, the relationship between SCA and Conflict disappeared.

Moreover, Age was significantly related to Switch Cost, that is, the younger the child the longer it took him/her to switch between the languages. This finding could be interpreted in two different ways. According to Meuter & Allport (1999) a switch cost asymmetry reflects a greater activation of Language 1, which means that the person is dominant in one language. It may be that younger children, who have less exposure to formal education, are less balanced bilinguals because they use mostly the language spoken at home, hence the more SCA. Alternatively, it may be that younger children are less able to inhibit the most dominant language, and show more asymmetry in the cost. Consequently this relationship may reflect a maturation of the neural networks responsible for inhibition and attention control (for a review see Bronson, 2002; Carlson, 2003; Rueda et al., 2004).

In conclusion, in this experiment bilingual and monolingual young children of low SES were tested in linguistic and non-linguistic executive tasks. To our knowledge, this was the first study to demonstrate no effect of bilingualism in both types of tasks when SES, general IQ, and vocabulary ability were well matched between the participant groups. Replicating these results while taking these factors into account would serve to further support the main argument made by this and our previous experiment: That low-SES may indeed attenuate the so-called bilingual advantage in attention over monolinguals, and executive functions overall, especially in young ages where one's cognitive capacities have not peaked yet.

3.9 General Discussion

The aim of this study was twofold: To see whether there is a bilingual effect in all three main attention networks and generally in executive control of children and to investigate the possible relations between the bilingual experience and attention effects once the participants are SES-matched and of low-SES level. The most striking finding was that bilingual children of low SES did not differ from their monolingual peers of the same SES level in any of the three main attention functions (executive, alertness, and orienting). Furthermore, bilingual and monolingual children of the same low SES did not differ in a linguistic task that resembles more closely the bilingual experience, the SI task.

Given that bilinguals intensively train in language-switching, suggested to involve executive control of attention among other functions, and the inter-communication between the main attention systems, why didn't this well-trained ability generalize to the linguistic executive control task or to the non-linguistic executive attention task but also to the other two main attention functions assessed the present study?

This lack of a bilingualism effect on executive attention opposes previous findings that showed a bilingual advantage over monolinguals in tasks of attentional control (e.g. Bialystok, 2006; Bialystok & Craik, 2010; Bialystok et al., 2005; Bialystok et al., 2009; Bialystok & De Pape, 2009; Colzato et al., 2008; Costa, Hernández & Sebastian-Galles, 2008; Fernandes et al., 2007; Festman, Rodriguez-Fornells & Münte, 2010; Hernández et al., 2010; Kharkhurin, 2010; Poulin-Dubois et al., 2011). This is also the case for previous empirical evidence on a bilingual benefit in drawing scalar implicatures (Siegal, Matsuo & Pond, 2007; Slabakova, 2009) and in pragmatic competence overall (Siegal, Surian, Matsuo, Geraci, Iozzi, Okumura et al., 2010; Siegal, Iozii & Surian, 2009; Surian, Tedodli & Siegal, 2010). Importantly, none of the studies on bilingualism and pragmatic competence controlled for the confound of SES. Specifically, the young adult participants of Slabakova (2009) were of middle-to-high SES, as they were university students, or in the case of children they either came from middle –class backgrounds as explicitly stated by the authors in one study (Siegal, Matsuo & Pond, 2007) or their parental education level was at least high-school education (Siegal et al., 2010; Siegal, Iozii & Surian, 2009; Surian, Tedodli & Siegal, 2010). Crucially, in the majority of research on a bilingual effect on cognition, SES has not been measured at all (Morton & Harper, 2007), although we carefully matched monolinguals and bilinguals for SES influences in the present study, and this is also the main difference of this study compared to previous ones. In addition, there have been also cases where SES may have not been balanced between the language groups. Specifically, in Bialystok and Martin (2004), the authors claimed that their participants were matched on SES as the geographic living location of monolinguals and bilinguals was in close proximity and of similar SES level. However, living and schooling locations are not always accurate indicators of SES, as for Experiment 1 we had to exclude many children due to their higher SES compared to the rest of our sample, despite the fact that all children were living in the same neighborhood and attending the same schools. Therefore, we suggest that previous findings on a bilingual benefit in attention may have been contaminated by the effects of SES. In this frame, it may also be that low SES may even attenuate this bilingual additive effect in cognition, as suggested by Morton and Harper (2007) and by our present results.

It is not the first time that low SES has been found to influence attentional control and attention overall. For example, SES disparities have been found in neuropsychological tests of executive function in adult samples (Singh-Manoux et al., 2005; Turrell et al., 2002). According to developmental studies, children of low SES tend to show poor self-regulation (Buckner, Mezzacappa & Beardslee, 2003), indicative of executive control immaturity. Additionally, children of middle SES outperformed their low SES peers in measures of executive control (Farah & Noble, 2005; Noble et al., 2005). Also, low SES - and specifically the low quality of the home environment- have shown to directly influence children’s inhibitory control and sustained attention (NICHD, 2003). Even more relevant to the present findings, a study involving a respectable sample size of children aged 5 to 7 years, similar to our participants in Experiment 2, and administering the ANT Child (Mezzacappa, 2004) found that higher SES children were faster and more efficient in the Alerting and executive attention trials of the ANT compared to lower SES participants. Thus, we consider the present results to be adding to the literature on the effects of SES in cognition.

There are several variables of the SES construct that have been theoretically and empirically shown to account for these disparities in cognitive tasks (for reviews see Bradley & Corwyn, 2002; Hackman & Farah, 2009). More specifically, the development of the prefrontal cortex seems to be directly influenced by parent-child interactions, parental education and income (Farah & Noble, 2005; Noble et al., 2005). Low parental education and income are especially important, as they seem to limit the development of attention (Conger *et al.*, 1994, 1995; Linver et al., 2002; NICHD, 2003). Other studies refer to parental provision of emotional support (e.g. emotion regulation) and cognitive stimulation at home (e.g. bedtime reading, joint attention events) as important environmental influences in attentional development (Bakeman & Adamson, 1984; Landry & Chapieski, 1989; Linver et al., 2002; Kochanska et al., 2000).

Culture is another social variable influencing cognitive functions, as has been well documented in the past (for a review see Markus & Kitayama, 1991). For example, it has been demonstrated that Chinese preschool children show superior executive functioning abilities as compared to children from Western cultures, such as the U.S. A plausible explanation for this effect is that Chinese culture values and encourages impulse control, which in turn is a central executive function characteristic (Chen et al., 1998; Ho, 1994;

Sabbagh et al., 2006; Wu, 1996). Interestingly, many of the studies of Bialystok and colleagues reporting a bilingual benefit in attention included Chinese or Cantonese children or adults in their bilingual group, though only English individuals in their monolingual groups (Bialystok, 2006; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok et al., 2005;).

Thus, it could be that the bilingual proficiency in control of attention reported in those studies is at least partly due to the participants' culture and not due to bilingualism *per sé*. This is also implied by Carlson and Melzoff (2008), suggesting that the bilingual research would benefit from studies replicating the results of Bialystok and colleagues without involving Chinese individuals. Importantly, our participants seem to be well matched in this variable, as they all came from collectivist cultures (Northern Greece and Albania; Eupedia, 2012).

Considering these, we wondered whether our data suggest that without the influence of culture and SES, the intensive cognitive training bilinguals undergo in language-switching does not have any effect whatsoever in their cognition. Despite the null differences between monolinguals and bilinguals in the attention and the SI tasks, our results in Experiment 1 do suggest a bilingual effect on executive attention, though of a magnitude not large enough to be detected when comparing the performance of bilinguals with that of monolinguals. We are referring to the relationship between the Conflict effect, reflecting executive attention ability, and L2 skill. This supports the findings of Segalowitz and Frenkiel-Fishman (2005), who showed that control of attention is related to skill in a second language, and suggested that bilingual proficiency (i.e. L2 Skill) is mediated by attentional control in a complex manner. The fact that this relationship was not found in Experiment 2 could be attributed to the age differences between the samples. That is, given the widespread changes that occur in the young brains during development in executive control and especially attention functions (for a review see Bronson, 2002; Carlson, 2003), important fluctuations in executive control of attention may appear as a function of age and hence mask any further influences in the cognitive system by other potentially weaker factors such as L2 skill.

Alternatively, it could be that because the children of the second experiment were younger than in Experiment 1, they also were exposed in and used an L2 for fewer years and therefore their less trained language-switching ability and generally L2 Skill did not influence their ability to resolve conflicting information. Thus, it seems that one must have enough years of intense training in switching between two languages, for this bilingual experience to exert an influence in the executive attention system, or any other attention function, strong enough to benefit bilinguals' performance over monolinguals, at least when isolating the confounding effect of SES as we did in this study. Put differently, perhaps one must be a balanced bilingual to show clear training effects in non-linguistic tasks of cognitive control. Unfortunately, to our knowledge, none of the previous studies showing a bilingual benefit in attentional control and claiming to have included balanced bilinguals has used a reaction-time task to assess the level of bilingual skill as in the present study. This would further enlighten the question of how balanced a bilingual must be to show a generalized proficiency in cognition. We believe that this is of high importance for future studies to consider.

A limitation of this study was that the SI task we used to measure children's pragmatic competence has been previously criticized for its sensitivity to the measured ability

(Katsos, 2009; Katsos & Bishop, 2011). That is, it has been suggested that the binary judgment SI task (i.e. asking the participant to provide a yes/no response) may not always require the computation of a scalar implicature to be responded to, as it also taps on the person's sensitivity to the informativeness of a sentence. For example, in a scenario where the child watches the video with all 3 horses jumping over a fence and the puppet stating that "some of the horses jumped over the fence" , the experimenter asks the child whether the puppet said it well or whether it should describe the video differently. For the child to reply correctly, instead of computing the scalar implicature, she/he may just be sensitive to the information provided by the video and think that the term "some" simply does not describe the video completely, without ever thinking that the opposite and correct term is "all", and hence reply correctly that the puppet did not say it well. Future studies should benefit from using SI tasks that control for sentence under-informativeness. An additional criticism of SI is that perhaps the semantic interpretation of a sentence needs not to be inhibited in order to activate and hence accept the pragmatic meaning, as the pragmatic meaning could act to narrow the semantic one (i.e. from "some and even all" to "some but not all"), thus it may act in addition to and not instead of the semantic meaning of a sentence (N. Katsos, personal communication, 4 January 2013).

However, this limitation should not overshadow the important contributions of this study to the literature in the cognitive effects of bilingualism: That non-linguistic, sociocultural factors may weaken and perhaps even attenuate bilingualism's effects in attention and control overall and that, in children at least, there does seem to be a weak bilingual effect in resolving conflict though not due to bilingual language-switching *per sé* as previously claimed, but due to the very fact of being bilingual which entails complex changes and interactions between linguistic experience and executive control of attention.

Chapter 4

Disentangling the effect of bilingualism in attention from socioeconomic influences in older ages.

Abstract

Literature suggests that it is possible to detect a bilingual benefit in a combination of executive control of attention and Working Memory (WM) functions relative to monolinguals, especially in older adults, due to age-related decreases in these functions which leave room for improvements from the cognitive training of bilingual language-switching in these functions. However, the problems in replicating this benefit imply that there may be factors confounding those findings, such as differences in the socioeconomic status (SES) of the participants. In addition, no study up to date has investigated the possible bilingual effect in the other two main attention functions, alerting and orienting. Also, the reliability of the self-reports usually employed to assess level of bilingual skill have suffered criticisms, thus making it difficult to conclude on the exact level of bilingual proficiency which is optimal for a bilingual advantage in attention to emerge. Thus, in this experiment older adults, either bilingual or monolingual, of equally low SES were tested in the three main attention functions and the Simon effect under different WM manipulations. A language-switching task was used as an objective measure of bilingual proficiency and as a means of revealing possible commonalities between the main attention functions and the ability to switch between languages. Results showed a bilingual benefit over monolinguals in executive attention under high WM load. It seems that in individuals of low SES, the bilingual advantage can only be

revealed with specific manipulations (old age of the participants, loading WM, balanced in switching between languages).

4.1 Introduction

With the adoption of globalization policies in the 21st century, which encourage the exchange of peoples, and the advances in communication technology bilingualism has come to characterize the majority of the population nowadays (Sebastián-Gallés & Bosch, 2001; Segalowitz & Frenkiel-Fishman, 2005; Siegal, Surian, Matsuo et al., 2010) and this population is continually aging due to increases in life-expectancy (Charness, 2008). Thus, with the enormous increase in the number of bilinguals who will be aged over 60 in the following years, it seems that establishing the possible cognitive impact of bilingualism in the mind of the elderly should become one of the priorities of cognitive research.

In young adults, a bilingual benefit has been shown in executive control of attention. This is evident usually in tasks presenting conflicting perceptual information (e.g. a left-pointing arrow presented at the right of the screen) and requiring a choice between competing response alternatives (e.g. press left key according to where the arrow is pointing at vs. right key according to the on-screen location it was presented). Bilinguals seem to resolve such conflict more efficiently than monolinguals, as they respond faster in these tasks (e.g. Bialystok & De Pape, 2009; Costa et al., 2009; Zied et al., 2004). This performance-superiority of bilinguals is attributed mainly to their constant need for language control, given that both languages are active in the bilingual mind during communication (Colomé, 2001; Costa & Caramaza, 1999; Costa, Miozzo, & Caramazza, 1999; Green, 1998; van Heuven, Schriefers, Dijkstra & Hagoort, 2008). As Bialystok

(2009) has proposed, the experience of controlling two language representations on an everyday basis can be viewed as a kind of cognitive training, whose effects would then generalize to other cognitive tasks requiring also attentional control. This hypothesis is also supported by neuroimaging data, which show that the mechanisms used to control the two languages are the ones also used in any task requiring control of attention (for a review see Abutalebi & Green, 2008), hence the generalization of the bilingual experience of language-control to other control tasks. However, if this is the case why are there studies which have failed to replicate the bilingual advantage with tasks tapping executive control?

One such an example is the finding of a bilingual advantage in the Simon task, which according to a recent study (Colzato, Bajo, van den Wildenberg et al., 2008) "…the reduced Simon effect –in bilinguals- seems notoriously difficult to replicate." (p. 302). Typically, in the Simon task, stimuli that differ in colour are presented either on the left or the right of fixation. The stimulus-response mappings are specific, so that for example a left key must be pressed when a yellow circle or right key must be pressed when a red circle appears on screen, by ignoring the stimulus position. The conflict or Simon effect is elicited when the position of the stimulus (e.g. left of fixation) is incongruent with the position of the response-key for that stimulus (e.g. the right key). Thus, the Simon effect mostly reflects the time required for executive attention processes to resolve the conflicting stimulus-response versus stimulus-location information (Bilaystok, Craik, Klein & Viswanathan, 2004). While several studies have shown that bilinguals have a significantly smaller Simon effect compared to monolinguals (e.g. Bialystok, Craik, Klein & Viswanathan, 2004), there are also studies that have failed to replicate this bilingual advantage (Bialystok, 2006; Bialystok, Martin & Viswanathan, 2005, exp. 2). In the words of Bialystok and colleagues (Bialystok, Martin & Viswanathan, 2005), the bilingual advantage is not always found as there are other factors, equally important to bilingualism, that may influence performance in attention tasks. To our view, these factors could be age and SES of the participants, which are further discussed.

Regarding age, the bilingual attentional benefit seems difficult to demonstrate in young adults, though it is more easily detected in older ones (Bialystok et al., 2004; Bialystok, Craik & Luk, 2008; Bialystok, Craik & Ryan, 2006; Bialystok, Craik & Ruocco, 2006); This occurs perhaps because young people are at the peak of their attentional capacities, in contrast to older individuals, thus leading to a ceiling effect which possibly masks a more subtle effect of bilingualism, revealed in later life (Bialystok, Martin & Viswanathan, 2005). Supporting evidence come from the rather limited number of studies with bilingual elderly, reporting a bilingual benefit in conflict resolution over monolinguals, however under different conditions or of a different magnitude (Bialystok et al., 2004; Bilaystok, Craik & Luk, 2008; Bialystok, Martin & Viswanathan, 2005; Bialystok, Craik & Ruocco, 2006; Bialystok, Craik & Ryan, 2006; Craik & Bialystok, 2006; Meuter & Simmond, 2007). For example, in one study using the dual-modality classification task, a bilingual benefit was detected only in conditions of low processing demands (Bialystok, Craik & Ruocco, 2006). On the contrary, a decreased Simon effect in the bilingual group of older adults compared to monolinguals was found in another study using the Simon task, though only in conditions with high-processing demands (Bialystok et al., 2004). In another three studies also employing the Simon task, results slightly differed. In Meuter and Simmond (2007), the typical age-related increase in the Simon effect was not found in the bilingual elderly and was interpreted by the authors as evidence of a protective effect of bilingualism in the processes reflected by the Simon. In Bialystok, Martin and Viswanathan (2005), bilinguals were faster than monolinguals not only in trials involving conflict, but in the ones eliciting facilitation as well. In another study (Bialystok, Craik & Luk, 2008), although bilingual elderly did perform faster than their monolingual peers in conflict trials, actually the Simon effect was not found at all in the bilingual group.

It seems then that the bilingual benefit in executive control of attention is indeed more clearly detected in older adults, in this way supporting the argument of age as one factor accounting for the difficulties in replicating the bilingual cognitive effect. Still however, there are inconsistencies in these findings, leading to the second factor that we mentioned which could function as a confounding in bilingual research: SES. We believe that this factor is particularly relevant since there is a substantial amount of evidence supporting the modulation of attentional function by SES (for a review see Magnuson & Duncan, 2006). That is, participants with a higher SES perform overall better than those with lower SES in attentional tasks (see also Mezzacappa, 2004). So it may be that the bilingual advantage shown in some of the studies mentioned above may be after all a socioeconomical advantage, since sometimes SES was not measured at all (Bialystok, Martin & Viswanathan, 2005; Meuter & Simmond, 2007). Other times, SES was inferred only from the education years of the participants (Bilaystok eta l., 2004; Bialystok, Craik & Luk, 2008; Bialystok, Craik & Ruocco, 2006), although it has long been acknowledged that years of education is but one of the two main variables constituting the complex SES construct, the other one being occupation, each of which uniquely contributes to SES's variability (o, 1961; Hollingnshead, 1971; for a review see Magnusin & Duncan, 2006). In line with this, in one study that carefully matched their groups for low-SES, an attenuated bilingual benefit in executive attention was found in a sample of children of low SES (Morton & Harper, 2007).) To our knowledge though, there is no study investigating possible influences of bilingualism in elderly individuals of low SES.

For these reasons, we aimed at investigating the effect of bilingualism on attentional function by rulling out the potential confound of young age and limiting possible SES influences. In order to do this, we tested elderly Albanian-Greek bilinguals and elderly Greek monolinguals, who were matched on low SES, in the ANT (Attentional Netowork Task) and the Simon tasks. Although the executive attention in old bilingual adults has been investigated in the past, this is the first time that the two other main functions of attention, alerting and orienting (Posner & Boies,1971; Posner & Petersen, 1990), are also examined. In young adults evidence is also scarce: We are aware of only one study on the effects of bilingualism in alerting and orienting (Costa, Hernández & Sebastián-Gallés, 2008) which found a bilingual benefit over monolinguals in alerting only and another on orienting and bilingualism (Hernández, Costa, Fuentes, Vivas & Sebastián-Gallés ,2010) also reporting no modulation of the orienting system by bilingualism. However, as the SES of those participants was middle or maybe even high, all being university undergraduates, we cannot know whether bilingualism will influence alerting and orienting in elderly of low SES.

In addition we employed a version of the Simon task which includes conditions of lower and higher working memory (WM) load (Bialystok et al., 2004). That is, in the low WM load condition, participants had to remember 2 stimulus-response mappings (2-

colors); whereas in the high WM load condition participants had to remember 4 stimulus-response mappings (4-colors).We decided to include this version of the task because research with elderly has shown that the bilingual positive effect on cognitive performance may emerge only under a high task-demands condition (Bialystok et al., 2004). Finally, we also included a numerical language-switching task (Meuter & Allport, 1999) to obtain a more objective measure of bilingual proficiency (in language-switching): Since the magnitude of the asymmetrical switch-cost from L1 to L2 and vice versa depends on the dominance level of each language, a person who is a balanced bilingual should not exhibit such asymmetrical switch-cost elicited by this task (Meuter & Allport, 1999). This is a novel aspect of the present study, since the majority of studies done previously have used self-report questionnaires to measure bilingualism (e.g. Costa, Hernández & Sebastian-Gallés, 2006; Garrat & Kelly, 2008; Portocarrero et al., 2007), which may reflect significant subjectivity on the part of respondents (for a review of Mindt et al.,2008).

Hypotheses

Simon task:

As previously shown, bilinguals will show a smaller Simon effect (i.e. experience less conflict) than monolinguals, though only under the high WM condition (Bialystok et al., 2004).

The Executive network of attention (ANT task)

According to our previous study with low-SES young adults and one with children of low SES (Morton and Harper, 2007), we predicted that elderly bilinguals will be equally proficient with monolinguals in resolving conflicting information.

The Alerting network of attention (ANT task):

Given the evidence on a bilingual benefit in the alerting function of young adults, we predicted that elderly bilinguals will be more aided by an Alerting cue (i.e. respond fster in trials with the Alerting cue) relative to their monolingual peers.

The Orienting network of attention (ANT task):

According to existing evidence with young people consistently showing a null bilingual effect in orienting (Costa, Hernández & Sebastián-Gallés 2008; Hernández et al., 2010), our prediction followed those results.

4.2 Method

Participants

The study was approved by the Ethics committee of City College, the Sheffield University International Faculty. Written informed consent was obtained from all participants (see Appendix B). Both groups were matched for age, SES level, general intelligence as measured by the Raven's SPM and vocabulary richness as measured by the Vocabulary subscale of the WAIS, Greek and Albanian version (see Table 4.1 for a description of these variables). Bilingual participants were equally skilled in the Greek and Albanian vocabulary.

The bilingual participants were recruited from a day care center for the elderly in Thessaloniki, Greece, situated in the western suburbs of the city. Participants were firstly contacted by telephone, with the telephone numbers provided by the day care center. Initially 55 Albanian elderly individuals were contacted, out of which 24 did not wish to participate, 2 did not speak Greek, 3 had a high education level (i.e. ≤12 years), 4 scored below 26 in the MoCA test (i.e. the threshold for healthy older adults: Nasreddine et al., 2005), and one had a serious vision impairment. Thus, 21 older adults (9 males, 12 females), bilingual in Albanian and Greek, of low SES and with a mean age of 68.76 (SD= 5.12) were included in the study.

The monolinguals were recruited from a day care center for the elderly in Xanthi, a city in Northern Greece near Thessaloniki, via posters and flyers disseminated at the center. Out of the 57 individuals who initially enrolled for the study, 14 refused to participate when contacted and 17 were rejected because they scored below 26 in the MoCA test (include reference). Thus, 26 elderly (7 males, 19 females), monolingual in Greek, of low SES and with a mean age of 68.92 (SD= 6.93) were included in the study.

Table 4.1. Demographic variables for study participants.

Variables	Monolinguals	Bilinguals
Age (years)[1]		
Mean	68.92	68.76
SD	6.93	5.12
Range	60-82	60-83
SES[1]		
Mean	2.19	2.05
SD	0.63	0.67
Range	1-3	1-3
G-WAIS Voc[1]		
Mean	29.08	25.57
SD	7.68	9.04
A-WAIS Voc		
Mean	-	22.46
SD	-	6.16
Raven's SPM[1]		
Mean	28.27	26.23
SD	6.27	5.92

SD = standard deviation
[1] Independent t-test: all > 0.05
G-WAIS Voc. = raw scores on the Geek version of WAIS Vocabulary subscale
A-WAIS Voc. = raw scores on the Albanian version of WAIS Vocabulary subscale
SES: 1 to 7= low SES, 8 to12= middle SES, ≤13= high SES

Material and Procedure

Each participant was individually tested in a quiet room, for approximately 1.5 hour. Although the tasks and tests that would be used were described briefly to participants, the exact aims of the study were withheld to minimize demand characteristics. Informed consent was obtained, after which the self-report Language Background Questionnaire was filled in by the participant, in the presence of the experimenter. The MoCA test was then administered and scored, so that only healthy participants would be included. After that, the rest of the screening measures and the experimental tasks followed, in a counterbalanced order for all participants.

Demographics and Language background questionnaire

This measure was based on similar ones previously used in bilingual studies (Abedi, Lord & Plummer, 1997; Brown, Bown & Eggett, 2009; Costa, Hernandez & Sebastian-Galles, 2008; Garrat & Kelly, 2008; Gullberg & Indefrey, 2003; Portocarrero et al., 2007). It was administered in the participants' native language (i.e. in Greek for the monolinguals, in Albanian for the bilinguals). A psychologist bilingual in Albanian and Greek rated the Albanian version of the questionnaire. For details on the design of this questionnaire and the scoring method, see Appendix I.

Intelligence and Vocabulary measures

In studies of the cognitive effects of bilingualism, it is essential to match participants for general intelligence (e.g. Colzato et al., 2008). Unfortunately, a widely used measure of intelligence has not yet been standardized for the Albanian population (e.g. Wasserman et al., 2000; Zimmerman et al., 2006). Thus, following previous studies of the bilingual effect on attention processes (Bialystok & Martin, 2004; Colzato et al., 2008; Treccani, Argyri, Sorace & Della Salla, 2009), the Raven's Standard Progressive Matrices (SPM; Raven, 1958) was used to measure general, non-verbal intelligence, which is considered a relatively culture-free, reliable and valid measure of Spearman's g (Raven, 2000; Wicherts et al., 2010).

Secondly, as an indicator of vocabulary proficiency, the expressive Vocabulary subtest of the Weschler Adult Intelligence Scale- version III (WAIS-III; 1997) was administered in both languages (i.e. Albanian and Greek). The WAIS has been widely used and standardized for the Greek population (Koulakoglou, 1998), though not for Albanians. To partially compensate for this limitation, a psychologist of Albanian nationality scored the bilingual participants on the Albanian vocabulary test, from their recorded answers.

Screening test for cognitive signs of dementia

The Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), a brief test of cognitive functions sensitive to dementia, was used to screen out participants with mild cognitive impairments. This test has been shown to have high sensitivity in detecting very early signs of cognitive deterioration in the elderly (Nazem et al., 2009).

Computerized tasks

All computerized tasks (the ANT, the Simon, the Language-switching task) were displayed on a 15-inch monitor of a laptop PC, using the E-Prime® 2.0 Professional software.

The ANT task

The ANT was adopted from Fan et al. (2002) with the difference that instead of the Double-cue (double asterisk) to alert the particpants, we included an auditory high-frequency tone of a short duration (Alerting cue). This change was made to enable more independent assessment of the three attention networks (Callejas, Lupiáñez & Tudela, 2004).

A cross (+) served as a fixation point. The target was an arrow pointing left or right, always presented centrally. The target arrow appeared either alone (neutral trial) or flanked by four identical arrows according to the condition (congruent or incongruent trial). There were also 4 cue conditions. All these conditions served to assess the 3 main attention networks, by conducting the appropriate calculations (see Figure 4.1).

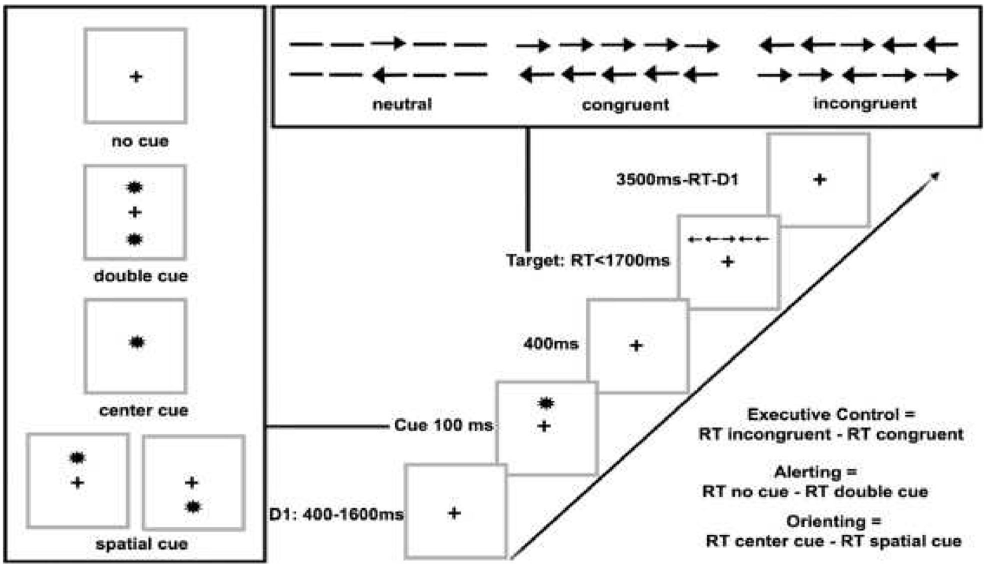

Fig. 4.1. All target (congruent, incongruent, neutral) and all cue conditions (no cue, alerting-sound cue –instead of “double cue”-, central cue, spatial cue) in an example of a typical ANT trial. The calculations for the 3 attentional networks are also depicted. Figure adopted from Vandenbossche et al. (2012).

The experiment included 24 practice trials, providing feedback to the participant, and three experimental blocks with 96 trials each without feedback. In total, 288 experimental trials were presented. Each trial was a combination of one of the 4 cueing conditions (central cue, alerting-sound cue, spatial cue, no cue) with one of the 3 flanker conditions (congruent, incongruent, neutral), and was presented 24 times (8 times in each block). Presentation order of trials was randomized.

The Simon task

The Simon task was adopted from Bialystok, Craik, Klein and Viswanathan (2004). Four conditions were included in the experiment: Centre-2 (a square either blue or brown appeared above or below fixation), Centre-4 (a square of one of four colours appeared above or below fixation: red, green, pink or yellow), Side-2 (an either brown or blue square appeared on the left or right of fixation) and Side-4 (identical to the Side-4 condition except that the square was presented left or right of fixation). The experiment consisted of two blocks: There were 96 experimental trials and 24 practice trials in each block, and 24 experimental trials per condition. The task always began with the Centre condition, which was the easiest one so that participants will get accustomed to it. Then, the Sides condition followed. This order was counterbalanced between blocks. The number-of-colours condition was randomized within each block.

In the beginning of each block, the instructions firstly appeared, followed by the practice trials. After that, the test trials began. Each trial began with a sound (a high tone "beep") (see Figure 4.2 for an example trial). In the 2-colours condition, participants were instructed to press the left key (marked "L") when they saw a blue square and the right key (marked "R") when they saw a brown square. The instructions for the 4-colours condition were presented as four separate rules, so as to maximize the WM load. Thus participants were instructed to press the left key when they saw a pink square, the left key when they saw a green square, the right key when they saw a yellow square and the right key when they saw a red square. The colour-key mapping was counterbalanced across participants.

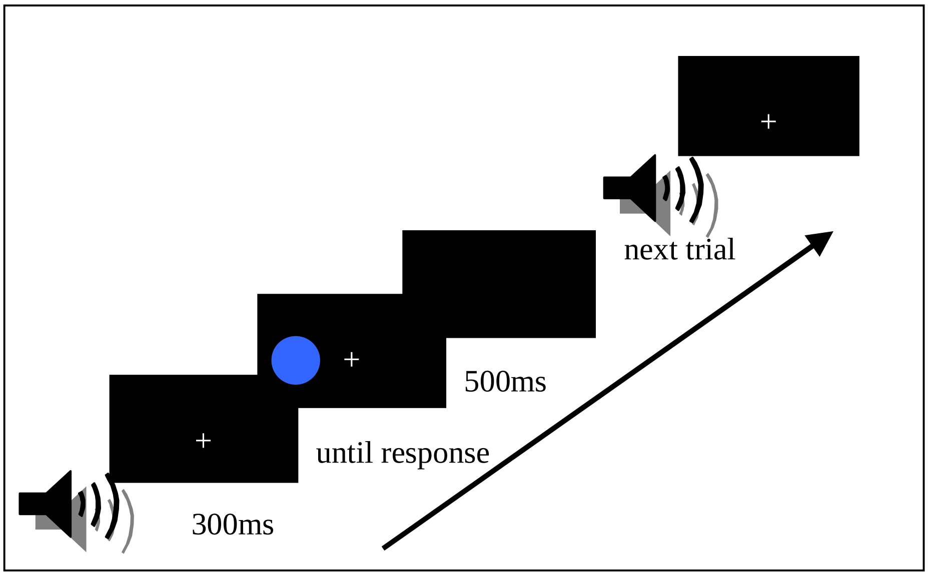

Fig. 4.2. The conditions and an example trial of the Simon task.

The Language-switching (LS) task

This task was similar to that of Meuter and Allport (1999). The target stimuli were yellow Arabic digits (1-9). The background was either a Greek or an Albanian colored flag (depending on the condition) serving as the language cue (i.e. it prompted participants to read the digit in that language). A microphone, connected to a voice key, was used to respond to the target. Participants were instructed to respond (i.e. read aloud the digit on the screen) as quickly and accurately as possible in the language suggested by the language-cue.

Trials were of two types: (1) non-switch trials where the language of response was the same as in the previous trial (70% of total trials), and (2) switch-trials where the language of response was different than the language used in the preceding trial (30% of total trials). Half of the switch and non-switch trials required a response in L1 and half in L2. The design of the task was pseudorandom: Generation of digits was random, however the same digit was not presented twice in a row. Each participant was presented with 10 practice trials and 300 testing trials in total. All trials were equally divided in 2 blocks of 150 trials each, 105 non-switch trials (70%) and 45 switch trials (30%). A short rest after completion of each block was optional.

Each trial lasted until response to target and the next trial onset took place 400ms after a response was recorded. Errors (either not following the language-cue, or reading the digit incorrectly) were recorded by the experimenter, by pressing the appropriate key after termination of each trial. An example of 2 non-switch and 1 switch-trial is depicted in Figure 4.3. Response latencies (RT) were recorded by the software.

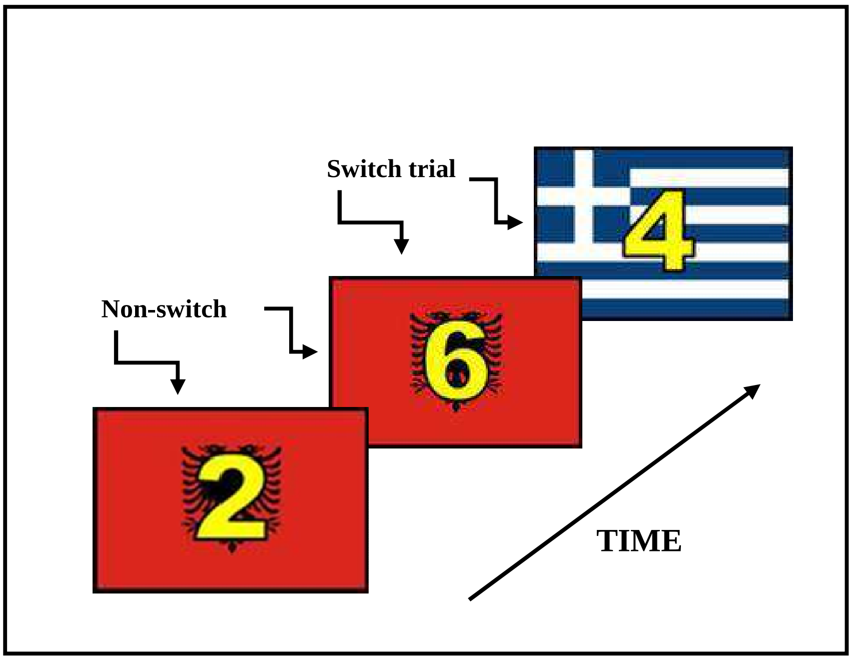

Fig. 4.3. Examples of both switch and non-switch trials in the Language Switching task.

4.3 Results

Computerized tasks

The ANT

Four monolinguals and 3 bilingual participants were excluded from the analyses because the percentage of incorrect Reponses was above 30%. Thus the response latencies and error rates of 22 monolingual and 18 bilingual older adults were included in the analysis. In addition, we excluded trials with response times of 2 SDs above and below the mean per cell in each participant. Calculations to obtain the three effects representing the function of the three main intentional networks were conducted according to Fan et al. (2002) and Rueda et al. (2004): For the Conflict effect reflecting the executive attention function, mean RT for the Incongruent trials were subtracted from mean RT for the Congruent trials, collapsing across Cueing conditions. For the Alerting effect, mean RT for the Alerting-cue was subtracted from mean RT for the No-cue trials, collapsing across Flanker conditions. To obtain the Orienting effect, mean RT for the Spatial-cue was subtracted from mean RT for the Central-cue trials, collapsing the data across Flanker conditions.

Error analysis

A 4 x 3 x 2 mixed ANOVA was used to analyze mean accuracy scores with Cueing (Alerting, No Cue, Central, Spatial) and Flanker (Congruent, Incongruent, Neutral) as the within-subject factors, and Language group (monolinguals and bilinguals) as the between-subject factor. Results showed a main effect of Flanker [$F(2, 76) = 6.408$, $p = .003$, $\eta^2 = .144$]. According to Bonferroni post-hoc tests, mean accuracy was lowest in the Incongruent (M= 0.95, SD= 0.01) compared to the Congruent condition (M= 0.98, SD=

0.01), *p*= .004. Additionally, a significant interaction between Cueing and Flanker was revealed [$F(6, 228)= 2.163$, $p= .048$, $\eta^2= .054$]. The post-hoc Scheffe test was used to further analyze this interaction, comparing mean error rates for all Flanker conditions in each Cueing condition. The interaction was due to the significantly higher error rates in the Incongruent relative to the Congruent condition only when the cue was central, *p*= .003. No further differences in error rates were observed. Thus the percentage of correct responses was comparable between the groups (monolinguals 97.31%, bilinguals 95.77%).

Response Times analysis

Mean correct RTs were analyzed using a 4 x 3 x 2 mixed ANOVA, with Cueing (Alerting, No Cue, Central, Spatial) and Flanker (Congruent, Incongruent, Neutral) as the within-subject factors, and Language group (monolinguals, bilinguals) as the between-subject factor (see Table 4.2). A significant main effect of Cueing was revealed [$F(3, 114)= 4.686$, $p= .004$, $\eta^2= .110$], with RT for the Spatial-cueing (M= 796.77, SD= 129.25) being significantly slower compared to the Alerting-cue (M= 773.50, SD= 130.51), *p*= .043 and the No-cue conditions (M= 764.00, SD= 130.55), *p*< .00001, as indicated by Bonferroni post-hoc comparisons.

The main effect of Flanker was also significant [$F(2, 76)= 74.171$, $p< .00001$, $\eta^2= .661$]. According to Bonferroni post-hoc comparisons, responses in the Incongruent condition (M= 859.97, 150.65) were the slowest relative to those for the Congruent (M= 748.28, SD= 135.33), *p*< .00001, and the Neutral conditions (M= 729.40, SD= 118.22), *p*< .00001, thus indicating a Conflict effect for all participants. Additionally, participants responded significantly faster in the Neutral compared to the Congruent condition, p= .039, showing an absence of a cueing-facilitation effect.

Table 4.2. Mean RTs (measured in milliseconds) and (SDs) at each experimental condition in the ANT.

Flanker type	**Language group**	**Cue type**				
		No cue	**Central cue**	**Alerting cue**	**Spatial cue**	**Mean Flanker**
Congruent	Monolinguals	711.14 (101.61)	762.00 (93.64)	743.77 (101.81)	781.07 (116.13)	749.50 (94.28)
	Bilinguals	763.61 (189.44)	719.32 (171.76)	740.64 (199.14)	763.61 (189.44)	746.80 (176.16)
Incongruent	Monolinguals	819.76 (105.65)	875.92 (88.11)	863.43 (100.46)	865.69 (86.15)	856.20 (82.66)
	Bilinguals	878.36 (217.36)	858.58 (252.52)	842.99 (173.68)	878.36 (217.36)	864.58 (208.77)
Neutral	Monolinguals	697.41 (87.30)	758.80 (105.82)	732.38 (89.78)	760.33 (95.83)	737.23 (85.15)
	Bilinguals	727.85 (142.34)	710.13 (189.83)	713.53 (179.44)	727.85 (142.34)	719.84 (151.42)
Mean Cueing	Monolinguals	742.77 (85.06)	798.91 (87.28)	779.86 (89.81)	802.36 (87.08)	
	Bilinguals	789.94 (169.90)	762.67 (191.69)	765.72 (170.28)	789.94 (169.90)	

Finally, the Cueing by Language group interaction was significant, [$F(3, 105)= 9.051$, $p< .00001$, $\eta^2= .192$]. This interaction was due to faster responses of the monolinguals in the No-cueing relative to all other cueing conditions, $ps< .05$, in contrast to the bilinguals who did not show such an effect (see Figure 4.4). This is probably due to limitations of the task we used, further discussed in the Discussion section. No other interaction reached significance.

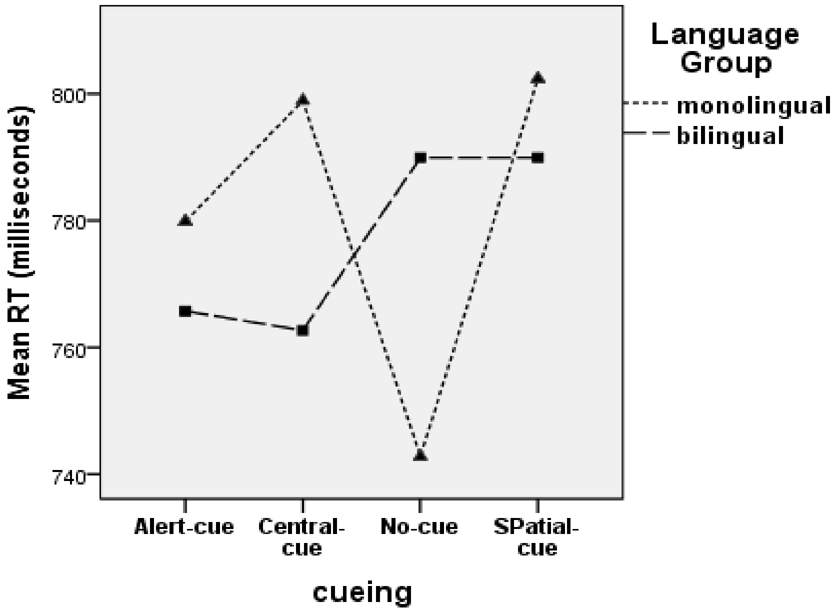

Fig. 4.4. The Cueing by Flanker significant interaction, with smaller conflict in the Spatial-cueing condition.

The Simon task

Four monolingual and 1 bilingual participants were excluded from the analyses because the percentage of incorrect Reponses was above 30% and/or had mean response times higher than 1500ms. Thus, correct response latencies and error rates of 22 monolingual and 20 bilingual older adults were included in the analysis. In addition, we excluded trials with response times of 2 SDs above and below the mean per cell in each participant.

Error analysis

Mean accuracy scores were analyzed by a 2 (Colour number: 2 and 4) x 2 (Congruency: congruent and incongruent) x 2 (Language group: monolinguals and bilinguals) mixed ANOVA, with Colour number and Congruency as the within-subject factors and Language group as the between-subject factor. Results showed a significant main effect of Color number, [$F(1, 40)= 4.960$, $p= .032$, $\eta^2= .110$], with significantly higher accuracy rates in the two (M= 0.96, SD= 0.03) compared to the four colours condition (M= 0.93, SD= 0.05). The main effect of Congruency was also significant, [$F(2, 80) = 6.699$, $p = .013$, $\eta^2 = .143$], with significantly higher accuracy rates in the Congruent (M= 0.96, SD= 0.04) compared to the Incongruent (M= 0.94, SD= 0.05) condition.

The Colour number by Congruency interaction was also significant, [$F(2, 80) = 5.454$, $p = .025$, $\eta^2 = .120$]. To investigate this interaction, we conducted planned comparisons between the Congruency conditions in each Colour number condition. The analysis showed that the interaction was due to the presence of the main effect of Congruency only in the 2-colours, $p < .00001$, and not in the 4-colours condition. The absence of a main effect of Language group and an interaction of the other two factors with Language group hsowed that mean accuracy scores were comparable between the two groups (monolinguals= 94.87%, bilinguals= 94.90%).

Response Times analysis

Correct mean response times were submitted to a 2 (Color number: 2 and 4) x 2 (Congruency: congruent and incongruent) x 2 (Language group: monolinguals and bilinguals) mixed ANOVA with Color number and Congruency as the within-subject factors, and Language group as the between-subject factor (see Table 4.3). The main effect of Color number was significant, [$F(1, 40) = 68.215$, $p < .00001$, $\eta^2 = .630$], with faster responses in the two-colors condition (M= 629.61, SD= 149.58) compared to the four-colors (M= 934.74, SD= 316.82). There was also a significant main effect of Congruency, [$F(2, 80) = 8.415$, $p < .00001$, $\eta^2 = .174$], with significantly faster responses in the Congruent (M= 716.12, SD= 190.11) relative to the Incongruent condition (M= 811.65, SD= 284.39).

Table 4.3. Means and (Standard Deviations) in all conditions of the Simon task, for monolinguals (N= 22) and bilinguals (N= 20).

Colour number	Group	Congruency		Simon effect
		Congruent	Incongruent	
2-colours	monolinguals	588.27 (90.45)	657.00 (108.16)	68.73*
	bilinguals	576.07 (162.51)	674.14 (233.57)	98.07*
4-colours	monolinguals	834.28 (217.02)	1038.02 (540.12)	**203.74***
	bilinguals	866.81 (336.89)	870.26 (338.94)	**3.45**

***** sign. at p < .05***

Finally, the three-way interaction between Colour number, Congruency and Language group was also significant, [$F(2, 82)= 3.919$, $p= .024$, $\eta^2= .089$]. To further investigate this interaction, two separate 2 (congruency) by 2 (language group) ANOVAs were conducted for each colour-number condition. In the 2-colours, only a main effect of congruency was revealed, [$F(1, 40)= 33.175$, $p< .0001$, $\eta^2= .453$], with significantly faster responses in the Congruent (M= 582.46, SD= 128.32) relative to the Incongruent condition (M= 665.16, SD= 177.02). Similarly in the 4-colours, there was also a main effect of congruency, [$F(1, 40)= 4.050$, $p= .051$, $\eta^2= .092$], with significantly faster responses in the Congruent (M= 849.77, SD= 277.47) compared to the Incongruent trials (M= 958.14, SD= 458.09). Additionally, in 4-colours, the interaction of Congruency by Language group was of marginal significance [$F(1, 40)= 3.785$, $p= .059$, $\eta^2= .086$]. According to planned t-tests, this interaction was due to the presence of a Simon effect (i.e. faster RT in Congruent vs. Incongruent condition) only in the monolingual group, as the responses of bilinguals to congruent and incongruent trials were equally fast (see Figure 4.5).

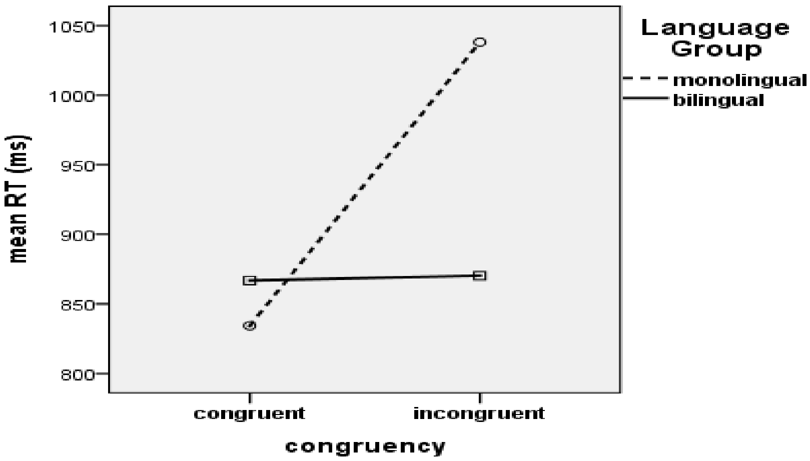

Fig. 4.5. The Simon effect in the 4-colours condition for monolinguals and bilinguals.
** sign. at p < .05*

To investigate whether this absence of conflict experienced by bilinguals in the 4-colours condition lies actually in an ability to better remember the stimulus-response mappings – that is, whether it depends on Working Memory (WM) ability - we assessed the difference in RT when the number of stimulus-response mappings increased. That is, we subtracted mean RT to respond to the 2-colours condition from mean RT to respond to the 4-colours trials, collapsing the data for Congruency. We then compared this WM cost between the two Language groups, using an independent t-test. No group differences were found.

The Language-switching task

Data from 3 bilingual participants were excluded, as their mean error rate was >30%. Thus, 18 bilinguals were included in the analysis, Mean correct RTs were submitted to a 2 x 2 within-subjects ANOVA, with Trial Language (Albanian and Greek) and Trial Type (non-switch and switch) as within subject factors. There was a significant main effect of Trial Type, [$F(1, 17) = 40.541$, $p < .00001$, $\eta^2 = .705$], with faster RT in non-switch (M= 892.72, SD= 189.40) compared to switch trials (M= 1047.30, SD= 237.81). No other main effect or interaction reached significance. Thus, an asymmetrical switch-cost was not observed which is consistent with the idea that the bilinguals of this study were balanced in the use of their two languages.

Data from this task, the two attention tasks and the Language Background questionnaire were further used to detect any possible commonalities in the mechanisms that serve the bilingual experience of language-switching, as indicated by the LS task, those used for resolving conflicting information of a non-linguistic nature as suggested by the ANT and Simon tasks as well as general skill in a second language derived from the Language Background Questionnaire. Specifically, we wanted to see whether the switch-cost (SC) that arises when switching between languages (i.e. the absolute mean RT to switch back to L2 minus the absolute mean RT to switch back to L1) was related to the Conflict effect from the ANT and/or the Simon effect, or any of the other two attention functions (Alerting and Orienting) and/or L2 Skill.

The SC, the Conflict, the Alerting, the Orienting and the Simon effects, as well as L2 Skill of our 18 bilinguals were submitted to a correlation analysis, applying the Bonferroni correction to adjust the significance level for multiple comparisons (alpha level = 0.007). As there were only 18 participants in this analysis, we used the Spearman's rho (see Table 4.4).

Table 4.4. Inter-correlations for measures of Switch Cost, Conflict, Alerting , Orienting, Simon in two and four-colours conditions and L2 Skill.

	Conflict	Alerting	Orienting	Simon 2-colours	Simon 4-colours	L2 Skill
SC	-.007	-.298	-.030	-.205	-.197	-.202
Conflict		.556	-.249	.199	.209	.060
Alerting			-.269	.131	-.026	.061
Orienting				.069	-.117	.034
Simon 2-colors					-.038	.526
Simon 4-colors						-.232

Contrary to our expectations, no significant relationship emerged betweenL2 Skill, the attention and the language-switching effects.

4.4 Discussion

In this study, we sought to investigate whether there is a bilingual benefit in executive attention and/or WM in older adults when controlling for SES. In our first study we failed to obtain a positive effect of bilingualism on attentional function in a sample of young adults. One explanation for this null effect may be that young adults are at the peak of their cognitive capabilities, and thus performed at ceiling in the cognitive tasks. Thus, perhaps the bilingual advantage can be more easily revealed in older adults who are not at the peak of cognitive performance due to cognitive decline with aging (Bialystok, Martin & Viswanathan, 2005), especially in the functions involved in control of attention (for a review see McDowd & Shaw, 2000). Another novel aspect of this study was that, apart from using a self-reported questionnaire to assess level of bilingualism, we included an RT task as a more objective measure of bilingual expertise, which also allowed us to investigate whether the bilingual experience in language-switching is related to attentional effects.

A bilingual advantage in attention over monolinguals was revealed by the Simon task, whereby bilinguals resolved conflict faster than monolinguals under conditions of high WM load, thus pointing to a bilingual benefit in a type of executive control involving both working memory -for keeping the sorting rule in mind- and control of attention -for avoiding distractor interference- as also supported by other studies with bilingual elderly (Bialystok et al., 2004; Bialystok, Martin & Viswanathan, 2005). What differentiates our study from previous ones is the low SES of both our participant groups. This underscores the reliability of this bilingual benefit as in the present study it was detected despite careful control of other, non-linguistic factors that could have confounded the results of past studies on bilingualism, such as middle or high SES or an SES mismatch between the participant groups. The reason why an effect of bilingualism did not emerge in the conflict trials of the ANT task may be attributable to the subtle nature of this effect, as previously alluded to (Bialystok et al., 2004; Bialystok, Craik & Ryan, 2006). That is, the magnitude of the bilingual effect may be so small that it is elicited only under very demanding conditions, such as in increased-WM load conflict trials in individuals with declining cognitive functions (e.g. elderly).

Level of bilingual expertise may have played an additional role in strengthening the bilingual effect we observed, as according to the results from the LS task our bilingual participants were balanced in the use of the two languages. This suggests that they have undergone prolonged cognitive training in language switching, which in turn benefited their executive control system.

The bilingual advantage in executive control of attention combined with WM reported herein may also reflect the very composition of the bilingual effect: Given that the performance of monolinguals and bilinguals was not statistically different in trials tapping either executive control of attention alone (i.e. conflict trials in ANT and low-WM conflict trials in the Simon) or WM alone (i.e. 2-colors and 4-colors conditions in the Simon task, collapsed for cueing), but it was superior in trials combining the two functions (i.e. high-WM trials of conflict in Simon task), it seems that lifelong experience in manipulating two languages offers a more general advantage in executive functions, as also demonstrated by other studies with older adults (Bialystok et al., 2004; Bialystok , Craik & Luk, 2008), and not only on control of attention. In addition, the fact that the bilingual benefit in EF emerged only in the high-WM load conditions suggests that perhaps the bilingual benefit is so subtle, that cognition has to be especially constrained to detect it. This is in line with the Load Theory of Attention (Lavie, Hirst, De Focker & Viding, 2004) according to which the interference of distractors is greatest under high WM conditions and has been previously supported by another study with elderly bilinguals (Bialystok, Craik & Luk, 2008; Bialystok et al., 2004).

Contrary to these findings, in the ANT bilingualism did not modulate any of the attention effects. This also contradicts previous evidence from one study with young adults where the ANT was also employed, showing a bilingual superiority in the Executive and the Alerting networks of attention (Costa, Hernández & Sebastián-Gallés, 2008). The fact that the participants of Costa and colleagues were probably of a middle-to-high SES, as they were university students, in contrast to our participants who were of low SES may imply that SES played a role in shaping the results. However, the anomalous results we received from the ANT in this study (i.e. absence of cueing effects for the Alerting and Orienting networks in the bilingual group, faster responses of the monolinguals when there was no cue present relative to all other cueing conditions, absence of a cueing-facilitation effect for both groups), despite consistent evidence on the reliability of the ANT in measuring the main attention networks in younger participants (e.g. Fan, McCandliss, Flombaum, & Posner, 2001; Fan, Wu, Fossella, & Posner, 2001; Fossella, Posner, Fan, Swanson, & Pfaff, 2002; Fossella et al., 2002) suggest that there may be limitations inherent in this task which constrain its reliability for use with elderly individuals. Evidence indirectly supporting this argument come from studies on the Inhibition Of Return (IOR) effect in elderly, according to which IOR appears later in older adults relative to younger individuals and this can only be detected with a task allowing for differential, extended Stimulus-Onset-Asynchronies (SOAs) (Castel et al., 2003). However, the present design o f the ANT does not include any time-course manipulations, thus leaving open the possibility that an age-effect masked the cueing effects the ANT could elicit in longer SOAs. This offers an avenue for future research to explore.

Finally, an interesting relationship emerged between executive control of attention and orienting. That is, we found that when attention was oriented to the upcoming target location by an orienting cue, the conflict effect for all participants, irrespectively of language group, was smaller than when an orienting cue was absent. A plausible explanation of this finding is that when attention is cued to the location where the target subsequently appears, it is easier to ignore the distractors because the focus is on the exact target location. However in the absence of a cue, the focus of attention is broadened to ensure target processing as the exact target location is not indicated. Consequently, processing of distractors which appear in close proximity to the target also takes place as they are included in the attentional focus. Thus, we concluded that the orienting attentional network exerts a positive influence on the executive network of attention, in agreement with Callejas et al. (2004; 2005).

The lack of a relationship between the cost of language-switching and any of the attention effects could be attributed to the rather limited size of the bilingual group, as in our previous experiments with 26 (experiment 1) and 28 children (experiment 2) important relationships between these variables emerged. Thus, we consider that it would be of interest for future studies to attempt investigating these relationships taking the sample size into account.

Concluding, this was the first time that a bilingual cognitive advantage was demonstrated in individuals of low SES. This advantage does not seem to be specific in executive control of attention, but to a combination of this function and WM. Given that executive control of attention and WM are functions very sensitive to aging (for a review see McDowd & Shaw, 2000; Bialystok, Martin & Viswanathan, 2005), and that bilingualism boosts performance in relevant tasks, it seems that tomorrow's older adults could be benefited by current policies promoting bilingualism. Another important conclusion was that the bilingual experience did not influence the orienting system, thus extending previous evidence from young adults (Costa, Hernández & Sebastian-Gallés, 2008). Replication of these findings is deemed necessary, given the mixed and even contradictory results of previous studies on the effects of bilingualism in attention, and also the specificity of this effect demonstrated herein.

Chapter 5

General conclusions

The principal aim of this thesis was to investigate for the first time whether bilingualism conveys a benefit to the three main attention functions throughout the lifespan, when controlling for SES influences. A secondary aim was to see how much experience in bilingual language-switching may be needed for a beneficial effect in attention to emerge, again while controlling for SES effects. Thirdly, an RT task was introduced to assess language-switching proficiency, to compensate for the subjectivity of self-reported measures on bilingual experience that have been used up to date, as well as to see, in combination to the results from the other cognitive tasks, whether it is the mechanism of language-switching that relates to the bilingual effects in cognition. Finally we also included two tasks, the SI and the Simon tasks, to investigate possible generalizations of the bilingual effect, if any, to the functions of WM and/or shifting, assuming that these tasks may be more relevant to the bilingual experience of language-switching. To this end, a series of four related experiments was conducted and described herein.

Several precautions were taken in the design of these experiments, to ensure the isolation of the bilingual effect in attention from other possible influences. Throughout the four experiments, we employed the ANT (Fan et al., 2002, and the modified version for children, Rueda et al., 2004) to assess the three main attention networks. By using the ANT task adopted for different age groups, we were able to provide more reliable evidence on the existence of a bilingual effect in attention within a lifespan trajectory by reducing incidental task variance between our experiments, as suggested by Bialystok, Matrin and Viswanathan (2005). Moreover, to grossly control for effects of culture in cognitive performance as suggested by Carlson and Melzoff (2008), in all experiments we included participants from collectivist cultures according to Eupedia (2012) (monolinguals in Greek, of Greek ethnicity; bilinguals in Albanian and Greek, of Albanian ethnicity). Finally, all participants were of low SES, as measured by a self-report (in the case of adults) or parental -report (in the case of children), to allow us to rule out SES as a possible confounding factor in the performance of our participants. One middle-SES group was also included in the first experiment, to provide more clear empirical evidence on the influences of SES in experiments of bilingual young adults.

In the first experiment we tested adults 18 to 61 years old. In contrast to numerous other studies (e.g. for a review see Bialystok et al., 2009; Costa, Hernández & Sebastián-Gallés 2008; Hernández et al., 2010), we found that bilingualism influenced the connections between the networks of Executive Control and Alerting, though no evidence to suggest that bilingualism directly modulates the three main attentional functions of Executive attention, Orienting and Alerting. We think it is likely that the low SES of our participants attenuated the cognitive effects of bilingualism, as reported by a previous study (Morton & Harper, 2007). The role of SES in cognitive performance was underlined by the speed advantage of the middle-SES group under all the ANT conditions observed in this experiment. In the past, bilinguals have been reported to perform faster than monolinguals in all conditions in executive attention tasks (i.e. the Simon task), which was taken as positive evidence on a bilingual effect which is not isolated in trials tapping conflict only, but spreads to congruent trials as well (Bialystok et al., 2004; Bialystok, Martin & Viswanathan, 2005). However, the monolinguals and the bilinguals of low SES in our experiment did not differ in mean RT under any condition, in contrast to the middle-SES monolingual group who outperformed both these groups. To our view, this is a clear demonstration of an SES effect which may have confounded past results.

We then asked whether bilingual children, who have experienced bilingualism for considerably fewer years than adults and whose attentional capacities are still developing, would show the same pattern of results. To address this question, we tested children aged from 6 to 11 years in the second experiment, of low SES. The same tasks were used, although adopted for these ages. The general pattern of results was repeated, with similar conflict, alerting and orienting effects in both language groups. Additionally, bilingual children's ability to resolve conflicting information was related to their self-reported skill of being bilingual (i.e. how well one speaks, comprehends, reads and writes in L2), which involves a wider combination of executive and other functions such as attention shifting and WM in addition to control of attention (Segalowitz & Frenkiel-Fishman, 2005). This suggested that perhaps a bilingual effect would be more salient in a task (a) tapping more a combination of general executive functions and (b) of a more linguistic nature, thus more relevant to the bilingual skill; salient enough to be detected when comparing the performance of bilinguals over monolinguals and even after controlling for SES. For this reason, we also included a task fulfilling these requirements (the SI task) in Experiment three. In addition, the results from the LS and the ANT tasks of Experiment two showed a subtle bilingual effect in conflict resolution when eliminating age fluctuations; that is, in the bilingual group their ability to resolve conflicting information, tapped from the ANT, was related to their ability to switch between the two languages or SCA, provided by the

LS task, when statistically controlling for Age. Therefore, in our third experiment we narrowed the age range by including children aged from 6 up to 7.8 years. We also tested a larger sample, to allow greater power for our statistical comparisons as indicated by power analysis.

According to the results of the third experiment, despite the aforementioned manipulations there was no bilingual benefit over monolinguals in executive attention, alerting or orienting. In addition, and contrary to previous findings (Siegal, Matsuo & Pond, 2007; Slabakova, 2009), bilingualism did not modulate children's pragmatic competence as measured by the SI task. To our view, these results suggest that perhaps the low SES of our participants attenuated the bilingual effect, similar to our previous two experiments with older children and young adults. More direct evidence on SES effects in the executive control of attention of bilingual children were provided by the relationship between their language-switching ability (i.e. the SCA variable) and their ability to resolve conflict (i.e. the conflict effect) when we statistically controlled for SES fluctuations in that group, despite the fact that they all belonged in the low SES category. This could imply that the mechanisms underlying language-switching and control of attention do share similarities, however they are sensitive to even slight individual differences in SES. There was also a negative relationship between SCA and the age of the bilingual children; that is, the younger the child, the slower he/she was to switch back to L1. There are two different explanations for this finding. First, it could be that the neural networks responsible for attentional control are still immature in younger ages (for a review see Bronson, 2002; Carlson, 2003; Rueda et al., 2004) and this is why younger children cannot quickly disengage from the strong inhibition used to suppress the dominant L1. Alternatively, L1 dominance may reflect younger children's less exposure to the bilingual experience (i.e. switching between two languages) proportionally to their age.

Hence in the fourth and final experiment we included older adults, who were expected to have accumulated experience and hence training in switching between languages (Bialystok, Craik & Luk, 2008). This repeated exposure in language-switching could strengthen any possible cognitive effect of such a bilingual experience and agrees with previous claims that the bilingual effect in executive control of attention seems to increase with age (Bialystok, Craik & Ruocco, 2006). An additional reason for including older monolinguals and bilinguals in the fourth experiment was the decline of cognitive function with aging, which potentially leaves room for improvements from cognitive training such as switching between two languages, thus making the effects of such training easier to detect (Bialystok, Martin & Viswanathan, 2005). That is, in older adults bilingualism may act as a buffer against cognitive decline. Furthermore, it has been suggested that the bilingualism positive effect may be more evident in tasks with high cognitive demands that load on WM (Bialystok, Craik & Luk, 2008; Bialystok et al., 2004). This is supported by the Load theory of Attention (Lavie, Hirst, De Focker & Viding, 2004), according to which the interference of distractors is greatest under high WM conditions. Thus, loading WM may reveal previously subtle language-group differences in executive control of attention.

In order to test this hypothesis, we also included a modified version of the Simon task in the fourth experiment. Specifically, apart from including the typical Simon conditions of stimulus-response incompatibility (e.g. right key-press to respond to a stimulus presented on the left of the screen) to assess executive attention, we also included conditions with lower (i.e. having to remember two stimulus-response rules) and higher WM demands (i.e. having to remember four such stimulus-response mappings). Interestingly the two functions involved in the Simon task, executive control of attention and WM (Bialystok, Martin & Viswanathan, 2005), are sensitive to age-related cognitive decline (Bialystok, Craik & Ryan, 2006). Thus, we expected that under these *optimal* circumstances a bilingual benefit on attention might be observed. The results of Experiment four revealed a bilingual additive effect in executive attention under high WM conditions, as evident by the almost null Simon effect of bilinguals relative to monolinguals in the high-WM load condition of the task. On the contrary, the language groups did not differ in the conflict effect from the ANT. These evidence suggests that the bilingual effect in cognition is probably weaker than expected, thus specific manipulations are required (i.e. high WM load, elderly participants) to reveal it. On the other hand, the bilingual advantage under these specific conditions seems strong enough to “survive” the negative influences low SES could have had in the performance of our participants.

There are a number of important findings reported in this thesis. The most striking one, as already mentioned, was that the performance of bilinguals and monolinguals in attention tasks was equal, in adults up to 60 years of age and in younger as well as older children, all of low SES. These results suggest that experience in bilingualism, defined as the amount of years of being bilingual (young children would have less experience in bilingualism), appears not to have a profound effect on the interaction between bilingualism and cognitive performance in these ages, as we found a similar pattern of results across the three age groups. In addition, these results make an important contribution to the literature on the effects of SES in cognition, suggesting as they do that the influence of low SES is so strong that it may entirely attenuate the so-called bilingual benefit in attention functions, reported by other studies. The negative impact that low SES can have in attention overall has been well documented in the past (Bakeman & Adamson, 1984; Kochanska *et al*., 2000; Landry & Chapieski, 1989; Linver *et al*., 2002; for a review see Magnuson & Duncan, 2006). Several SES variables have been theoretically and empirically shown to account for disparities in cognitive tasks (for reviews see Bradley & Corwyn, 2002; Hackman & Farah, 2009). For example, the development of the prefrontal cortex has been shown to be directly influenced by parent-child interactions, parental education and income (Farah & Noble, 2005; Noble et al., 2005). Other studies refer to parental provision of emotional support (e.g. emotion regulation) and cognitive stimulation at home (e.g. bedtime reading, joint attention events) as being important SES-related environmental influences in attentional development (Bakeman & Adamson, 1984; Landry & Chapieski, 1989; Linver et al., 2002; Kochanska et al., 2000).

With regard to bilingualism, it has long been acknowledged that social variables such as SES have to be carefully measured and balanced between the participant groups when studying the cognitive effects of bilingualism (Cummins, 1976; Reynolds, 1991). A clearer demonstration of SES influences in bilingual studies was offered by Experiment one, where a middle-SES group of monolinguals was also included to allow comparison of language groups of different SES. Firstly, the general intelligence of the middle-SES participants was higher than that of bilinguals who were matched in low SES and general intelligence with the other monolingual group. This indicates that the previously-documented effects of SES on intelligence is apparent in our participants and may influence performance in other cognitive tasks, thus underscoring the importance of including groups of equally low-SES in studies of cognitive functions. Secondly, a general speed advantage on the ANT was observed in the middle-SES group compared to the other two groups. We attributed this to a possible lack of computer skills of our bilingual and monolingual low-SES participants, as people from low-SES backgrounds tend to have professions that are more manual in nature. Computer familiarity has been shown to boost performance in computerized cognitive tasks (e.g. Bialystok, 2006; Hérnandez et al., 2010). Similarly, in the past bilinguals have provided faster responses in all experimental conditions in executive control tasks, which was attributed to a bilingual advantage in responding to conditions requiring control of attention (Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Martin & Viswanathan, 2005). However, the participants of those studies were not matched for SES, leaving open the possibility that this speed advantage was due to an SES-related variable such as greater familiarity with computers, rather than being related to bilingualism *per sé*.

The possibility of a confound of bilingualism and SES is further supported by Morton and Harper (2007), according to whom the bilingual participants of many studies (e.g. Bialystok, 1999; Bialystok, 1986, Experiment 1; Bialystok & Martin, 2004; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005; Bialystok & Viswanathan, 2009) were possibly of a higher SES than their monolingual counterparts. That is, bilingual participants in those studies tended to come from immigrant Canadian families whereas monolingual participants came from non-immigrant Canadian families. Due to the Canadian immigration policy which places great emphasis on academic achievement, Canadian immigrants tend to have a higher education level than the vast majority of non-immigrants (Statistics Canada, 2003a). Thus, it could be that the performance differences between bilinguals and monolinguals of those studies should be attributed to the possibly higher SES of their bilinguals and not to any effect of bilingualism. Similarly, other studies have failed to properly measure and control for SES influences, by making vague assumptions about SES. For instance, several studies have assumed that bilingual and monolingual samples had the same SES because participants lived in the same area, or attended the same schools (Bialystok and Martin, 2004). However, living and schooling locations are far from accurate indicators of SES, as illustrated by Experiment two where we had to exclude many children due to their higher SES compared to the rest of our sample, despite the fact that the living and schooling arrangements of all children we recruited were identical.

Another factor that may account for the lack of replication of the bilingualism effect in our study is culture, as this factor has also been shown to influence cognition (for a review see Markus & Kitayama, 1991). For example, Chinese preschool children reportedly show superior executive functioning abilities when compared to children from more individualistic western societies. This finding has been attributed to the greater emphasis on self-regulation/control by the Chinese culture, which is a fundamental executive function skill (Chen et al., 1998; Ho, 1994; Sabbagh et al., 2006; Wu, 1996). This factor has not usually been considered in studies of bilingualism, which often compare Chinese or Cantonese-English bilingual with English monolingual groups (Bialystok, 2006; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok et al., 2005). In our study, we included participants from collectivist cultures only (Northern Greece and Albania; Eupedia, 2012). In sum, the lack of replication of the bilingualism benefit on cognitive performance in our study offers grounds for thinking that failing to control for mediators of cognitive performance such as culture and SES may have overestimated the influence of bilingualism on attention.

Although we did not replicate the difference between monolinguals and bilinguals in cognitive performance, we did observe that bilingualism influenced the connections between the two networks of Alerting and Executive Control of attention in young adults. Specifically, in Experiment one under alerting conditions (i.e. double-cueing in the ANT), the magnitude of the conflict effect was larger for bilinguals relative to monolinguals, suggesting that the Executive network of bilinguals was “shut down” under alerting conditions. Although this may seem counter-intuitive at first sight, it could be interpetted as a positive influence of bilingualism in the functional value of the Alerting network of attention. That is, by deactivating the Executive control attentional network which engages the cognitive system in a relatively time-consuming elaboration of a stimulus, the system prioritizes the detection of the upcoming, maybe threatening stimulus (which is the role of the Alerting system). In partial support of this argument, neuroimaging evidence have shown that in trials where Alerting is involved, the efficiency of the Excutive attentional Control network decreases (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005, Fuentes, Vivas**,** Langley, Chen, & Gonzales-Salinas, 2011). A possible explanation of how bilingualism influences alerting could be that a bilingual individual needs to stay alert to external cues that would indicate which language to use in a given circumstance and this may generalize to situations also involving alerting stimuli, though of a non-linguistic nature such as the alerting-cue condition in the ANT. We attribute the lack of a bilingual advantage in alerting in our other experiments to two reasons: Firstly, regarding older adults, it could reflect a limitation of the task used to elicit Alerting; that is, the overall ANT results of Experiment four showed an anomalous pattern of cueing effects (the Alerting and Orienting effects were not elicited at all in bilinguals and the absence of a cue was the most facilitating condition for the monolinguals). This was attributed to the task design which does not allow for manipulations of the SOAs, thus probably masking the attentional effects that could be detected in longer SOAs as previous research with attention effects in elderly has shown (Castel et al., 2003). Future research could investigate this possibility further, as we lack direct empirical evidence to support this. Secondly, alerting did not differ as a function of language group in our experiments with children perhaps due to their lack of bilingual experience. That is, the bilingual children we tested were not balanced in language-switching, although our young adult bilinguals were. Therefore, the training effects of such intense cognitive switching were strong enough only in adults to generalize to other cognitive tasks as well.

We also observed a relationship between bilingualism and conflict resolution. That is, the asymmetry of the cost of switching between languages was significantly correlated with the magnitude of the conflict effect in Experiments two and three. In other words, the more balanced the bilingual participants were, the better they resolved the cognitive conflict (flanker effect in the ANT task). This is consistent with the view that these two tasks share common underlying mechanisms (for reviews see Bialystok, 2009; Bialystok, Craik, Green & Gollan, 2009) and this may be the reason why bilingualism, or experience in language-switching, exerts an influence in executive control of attention.

This finding also suggests that the term "experience" in language-switching does not reflect the amount of years a person has been bilingual. Instead, it stands for the frequency with which one switches between languages and this is what can be viewed as the bilingual cognitive training, which may generalize to tasks assessing related functions. A prediction deriving from this argument would be that as long as a bilingual is balanced, he/she should show such training effects in other tasks which resemble this "bilingual experience", such as the SI task we employed in Experiment three. Although such a bilingual effect was not observed in that experiment, it could be attributed to the fact that according to the LS task the bilingual children of that experiment were not balanced bilinguals, in contrast to the parental reports on frequency of dual-language use, hence the null "bilingual training effect" in a linguistic task involving executive attention and attention shifting. However, the adults of Experiment one were balanced according to the LS task. Thus, according to the aforementioned prediction, we would expect a language-switching generalization effect to other executive attention functions, such as the conflict effect from the ANT. It is perhaps slightly surprising that such a finding was not evident in Experiment one, though this may be attributable to a ceiling effect, as during adulthood one's cognitive capacities are at peak (in contrast to children and older adults), hence they may mask an effect of bilingualism which is smaller in magnitude. The null relationship between SCA and Conflict in the same experiment further supports such a masking age-effect.

The results of Experiment four on the other hand, offers strong support for this prediction. That is, bilinguals of low SES resolved conflict faster than monolinguals, of equally low SES, in the Simon task under conditions of high WM load. According to the “bilingual experience” hypothesis, this bilingual advantage could well be attributed to the fact that the participants of that study were balanced bilinguals, as demonstrated by the LS task which was used as an index of bilingual experience in language-switching. In addition, by including elderly participants we controlled for a possible ceiling effect of age and hence detected the bilingual benefit in executive functions. This may also suggest that bilingualism offers a buffer against the cognitive decline characterizing elderly individuals especially in such higher-order functions. Alternatively, or in addition to the above, the bilingual advantage in that experiment was salient enough to be detected because the WM demands were increased, in line with the Load theory of Attention.

Finally, three out of the four experiments described in this thesis provided important evidence on the functional relationship between the three main attention networks. The fact that we included different age groups in each experiment and that we used the ANT task to assess attention in all experiments, while simultaneously controlling for SES and cultural influences to which attention is sensitive, enabled us to provide more reliable evidence on the mutual influences between the three main attention networks throughout the lifespan. In detail, in children (Experiments 2 &3) we found that the efficiency of the Executive Control attention network was increased (i.e. the Conflict effect was smaller in magnitude) when the Alerting and the Orienting functions were not involved. Neuroimaging studies with young adults partially support this view (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005, Fuentes, Vivas**,** Langley, Chen,

& Gonzales-Salinas, 2011). Specifically, they have demonstrated that in conditions of alertness (a temporal cue is present) where the right frontal cortex is activated, the anterior cingulate cortex, which is part of the executive attention network, is deactivated. Consequently, the efficiency of the Executive attentional Control network decreases in trials where the Alerting network is involved. The role of this negative relationship between the Alerting and the Executive attention networks could be adaptive, as argued earlier. That is, alerting serves to detect an infrequent, and maybe threatening, stimulus; however the Executive attention network elicits further and hence more time-consuming processing of that stimulus (Callejas, Lupiáñez & Tudela, 2004). This more elaborate processing may not allow the cognitive system to detect a threat that follows (which is the role of the Alerting network), as it will still be engaged in processing the previous stimulus, hence the adaptive value of the negative connections between Alerting and Executive Control of attention. However, past studies clearly contradict the negative influence of the Orienting to the Executive control attentional network (Callejas, Lupiáñez & Tudela, 2004; Callejas, Lupiáñez, Funes & Tudela, 2005) and unfortunately we cannot currently offer an explanation for this effect.

Moreover, in Experiment two we observed that in children, the Alerting network positively influences Orienting of attention. Put differently, the cueing effect of an orienting cue was larger after an alerting signal, a finding which is consistent with previous studies (Callejas, Lupiáñez & Tudela, 2004; Fuentes & Campoy, 2008; Robertson,Tegnér, Tham, & Nimmo-Smith, 1995; Thimm, Fink, Kust, Karbe, & Sturm, 2006). However in young adults (Experiment 1) this picture was reversed, as Alerting and Orienting were negatively related. That is, the larger the alerting effect of the participants, the smaller the magnitude of their orienting effect as indicated in a correlation analysis of all the attention effects. This finding contradicts our previous findings and those of other studies (Fuentes & Campoy, 2008; Robertson, Tegnér, Tham, & Nimmo-Smith, 1995; Thimm, Fink, Kust, Karbe, & Sturm, 2006). However, it may be that the lower SES of our participants relevant to those studies and their different ages influenced the relationships between Alerting and Orienting of attention in a complex manner which resulted in their negative relationship; the important influences that age and SES exert on Alerting and Orienting have been demonstrated in the past (Mezzacappa, 2004; Rueda et al., 2004), although it is not obvious how best to explain this reversed relationship. This may be a fruitful avenue for future empirical work.

Taken together, the three experiments with children and adults described here provide evidence regarding the modulations between the three main attention networks while for the first time matching the participants for low-SES and minimizing possible cultural differences in all these age groups. The importance of revealing the relationships between the main attention functions is underscored by Mezzacappa (2004), who stated that "the basic processes of alerting, orienting, and executive attention are fundamental to all forms and complexity of conscious cognitive activity and social behavior" (p. 1373).

Despite the important new contributions made by our findings, the limitations should also be emphasized. Firstly, according to power analysis, the ideal sample size for maximal power in Experiment one would be 66 participants, although we included 57 in total. Additionally, in experiment two, post-hoc power analysis indicated that the power achieved with the sample size of 48 children was 0.92, although ideally we should have included 54 children. However, we do not believe that the null findings regarding a bilingual benefit over monolinguals in those experiments should be attributed to the sample size, as a cognitive advantage of bilingualism has been previously demonstrated with the same-sized sample (Bialystok & Shapero, 2005, exp. 1) or even smaller samples in both children (e.g. Bialystok, 1988; Martin-Rhee & Bialystok, 2008) and adults (e.g. Bialystok et al., 2005; Bialystok & DePape, 2009). Also, the data did not show a tendency for a difference between the groups in the direction predicted by previous literature.

In addition, no widely used measure of intelligence has been standardized for the Albanian population yet (Wasserman et al., 2003; Zimmerman et al., 2006). To compensate for this limitation, we firstly used a test of non-verbal intelligence, the Raven’s tests for adults and children, which are considered relatively culture-free, reliable and valid measures of Spearman’s g (Raven, 2000; Wicherts et al., 2010). Secondly, to compensate for the lack of proper (i.e. Albanian) norms for these tests, we used only the raw scores as a means of comparison of general intelligence between the monolingual and bilingual groups. Similarly, only the raw scores of the WAIS and WISC Vocabulary subscales were used and only for balancing the bilingual and monolingual groups in vocabulary richness. Thirdly, the items of the two Vocabulary scales from the WAIS and the WISC were translated and scored by a psychologist of Albanian ethnicity, proficient in the Greek language and trained to use these tests. Thus, we believe that our manipulations allowed us to reliably balance our participants in general intelligence and vocabulary richness.

Another issue which could be considered a limitation is that, although we adopted a lifespan approach and used the same basic attention and language-switching tasks in all four experiments and the same inclusion criteria and measures of demographics, general intelligence and expressive vocabulary to enable reliable demonstration of a bilingual effect in attention throughout life when controlling for non-linguistic confounding factors, our children participants (Experiments 2 & 3) were not balanced bilinguals as opposed to the adult participants of Experiemnts one and four. This is a methodological limitation, as we used the Language Background questionnaire to screen out dominant bilingual children instead of the LS task which, according to the LS results in Experiemnts two and three, showed that the children were dominant bilinguals despite the parental statements suggesting otherwise. Future studies could use an RT task such as the LS task instead of a self-report measure to ensure homogeneity in level of bilingual skill in language-switching between different bilingual groups. Nevertheless, this also underscores the very reason why we used the LS task, which was to safeguard against the subjectivity of self-report measures on language-use that have been used up to date to define whether a bilingual is balanced or not.

An additional difference between our experiments was in the ANT task design: In Experiemnts three and four, we used an auditory cue as the alerting cue, instead of a double asterisk used in Experiemnts one and two. As argued earlier, this manipulation targeted at a more independent assessment of the Alerting ftom the Orienting network in line with previous research (Callejas, Lupiáñez & Tudela, 2004). Although this is a small differentiation of the ANT task design in half of the experiments of this thesis, it did not seem to influence participants' performance. This was suggested by the interactions between the main attention networks in Experiments two and three, which followed the same pattern despite this manipulation.

This investigation has contributed to the understanding of the consequences of bilingualism in attention throughout the lifespan and the mechanisms underlying the so-called “bilingual effect”, by eliminating specific confounding factors previously shown to influence attention, such as SES, which may have undermined the validity of previous evidence on the bilingual effects in cognition. In addition, a computerized task was used for the first time to further elucidate the relations between the bilingual experience and specific attention effects, as well as to provide evidence on how much experience in bilingual language-switching (as measured by level of activation of both languages) is needed to have an effect in cognition.

Future studies could also use such a language-switching task in combination to other attention tasks with bilinguals of differential language-switching proficiency levels and of different ages, to offer more detailed information on this question. Other manipulations which could further enlighten the mechanisms of the bilingual advantage in cognition could be to also use both a language-switching task and a task specifically measuring skill in a second language (i.e. how well a bilingual reads, comprehends, writes and speaks in L2); this could offer evidence on whether these two bilingual abilities, skill in L2 and proficiency in language-switching, act independently or in combination to influence the bilingual cognitive effects.

Moreover, replication of the present findings with divergent samples would serve to answer whether differences in culture or in the languages spoken by a bilingual individual allow for the generalization of the present conclusions to the wider population of bilinguals. For example, an interesting line of research would be to compare the performance of individuals bilingual in linguistically similar languages versus those who speak two very different languages, as it could be that when the languages spoken are similar (e.g. Italian and Spanish), hence interference between L1 and L2 is possibly greater, then the control mechanism responsible for selecting the appropriate linguistic set is more trained compared to the language control mechanism of bilinguals speaking languages that overlap less due to large linguistic differences (e.g. English and Chinese). In turn, such more intense cognitive training in language selection could be reflected in different-in-magnitude or quality bilingual effects in cognition. At this point, it should be mentioned that Albanian and Greek are claimed to be very similar languages grammatically, with similar case systems and verb conjugation systems, as they both belong to the same Indo-European branch according to some linguists (Mallory & Adams, 2006; Holm, 2010). Disentangling the SES influences in the attention system of bilinguals, for example comparing the cognitive performance of bilinguals of differential SES levels, would be another fruitful pathway for future research. An additional research avenue would be to see whether differential WM loading can reveal a bilingual cognitive effect in participants of younger ages and especially children, given the strong influences of age in WM ability (Rypma & D' Esposito, 2000; Van der Linden, Bredart, & Beerten, 1994). Our results also warrant deeper investigation of the negative relationship between the Alerting and the Orienting networks, as to date there is no empirical evidence to support this.

Concluding, it should be emphasized that although a bilingual benefit over monolinguals in Executive attentional Control was found only in elderly individuals, the important implications of this finding should not be underestimated: The negative consequences of cognitive ageing in general executive functions (Moscovitch &

Winocur, 1992) and especially executive attention (Connelly, Hasher, & Zacks, 1991; Hasher & Zacks, 1988; Zacks, Hasher, & Li, 2000) have now been well-established. Our results in addition to previous ones (Bialystok et al., 2004; Bialystok, Craik & Luk, 2008; Bialystok, Craik & Ryan, 2006; Bialystok, Craik & Ruocco, 2006) have demonstrated the beneficial effects of bilingualism in exactly these functions. It seems, therefore, that this evidence offers fruitful grounds for future implementations of bilingual education as a means of protection from age-related cognitive decline (Bialystok, Craik & Luk, 2008). This is particularly important for today's modern societies, given that due to improved health services life expectancy has grown substantially, consequently leading to increases in ageing rates over and above birth rates (Charness, 2008).

6. References

Abedi, J., Lord, C., & Plummer, J. R. (1997). *Final Report of Language Background as a Variable in NAEP Mathematics Performance.* CSE Technical Report 429, Los Angeles: University of California.

Abutalebi, J., & Green, D.W. (2007). Bilingual language production: The neurocognition of language representation and control. *Journal of Neurolinguistics, 20,* 242–275.

Abutalebi, J., & Green, D.W. (2008). Control mechanisms in bilingual language production: Neural evidence from language switching studies. *Language and Cognitive Processes, 23,* 557-582.

Allport, A., Styles, E.A., Hsieh, S.L., 1994. Shifting intentional set: Exploring the dynamic control of tasks. *Atten. Perform. Xv 15,* 421–452.

Bakeman, R., & Adamson, L.B. (1984). Coordinating attention to people and objects in mother–infant and peer–infant interaction. *Child Development, 55,* 1278–1289.

Benetou, V., Chloptsios, Y., Zavitsanos, X., Karalis, D., Naska, A., & Trichopoulou, A.(2000). Total cholesterol and HDL-cholesterol in relation to socioeconomic status in a sample of 11,645 Greek adults: the EPIC study in Greece. *Scandinavian Journal of Public Health, 28,* 260–265.

Bentin, S., Kutas, M., & Hillyard, S. A. (1995). Semantic processing and memory for attended and unattended words in dichotic listening: Behavioral and electrophysiological evidence. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 54-67.

Ben-Zeev, S. (1977). The influence of bilingualism on cognitive strategy and cognitive development. *Child Development, 48*, 1009–1018.

Bialystok, E. (1986). Factors in the growth of linguistic awareness. *Child Development*, 57, 498–510.

Bialystok, E. (1988). Levels of bilingualism and levels of linguistic awareness. *Developmental Psychology*, 24, 560– 567.

Bialystok, E. (1999). Cognitive complexity and attentional control in the bilingual mind. *Child Development, 70,* 636-644.

Bialystok, E. (2001). *Bilingualism in development: Language. literacy, and cognition.* New York: Cambridge University Press.

Bialystok, E. (2006). Effect of bilingualism and computer video game experience on the Simon task. Canadian Journal of Experimental Psychology, 60, 68-79.

Bialystok, E. (2009). Claiming evidence from non-evidence: a reply to Morton and Harper. *Developmental Science, 12,* 499-501.

Bialystok, E. (2010). Global–Local and Trail-Making Tasks by monolingual and bilingual children: Beyond inhibition. *Developmental Psychology, 46,* 93–105.

Bialystok, E., & Craik, F. I. M. (2010). Cognitive and Linguistic Processing in the Bilingual Mind. Current Directions in Psychological Science, 19, 19-23.

Bialystok, E., Craik, F. I. M., Grady, C., Chau, W., Ishii, R., Gunji, A., et al. (2005). Effect of bilingualism on cognitive control in the Simon task: evidence from MEG. *NeuroImage, 24,* 40– 49.

Bialystok, E., Craik, F. I. M., Green, D. W., & Gollan, T. H. (2009). Bilingual Minds. Psychological Science in the public Interest, 10, 89-129.

Bialystok, E., Craik, F.I.M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: Evidence from the Simon task. *Psychology and Aging, 19,* 290–303.

Bialystok, E., Craik, F., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory and Cognition, 34,* 859-873.

Bialystok, E., Craik, F., & Luk, G. (2012). Bilingualism: consequences for mind and brain. *Trends in Cognitive Sciences, 16,* 240-250.

Bialystok, E., Craik, F. I. M., & Ruocco, A. C. (2006). Dual-modality monitoring in a classification task: The effects of bilingualism and aging. *Quarterly Journal of Experimental Psychology, 59,* 1968–1983.

Bialystok, E., Craik, F. I. M., & Ryan, J. (2006). Executive control in a modified anti-saccade task: Effects on aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,*1341–1354.

Bialystok, E. & DePape, A. M. (2009). Musical expertise, bilingualism and executive functioning. Journal of Experimental Psychology: *Human Perception and Performance, 35,* 565-574.

Bialystok, E., & Feng, X. (2009). Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults. *Brain and Language, 109,* 93–100.

Bialystok, E. & Feng, X. (2011). Language proficiency and its implications for monolingual and bilingual children. In: Durgunoglu, A. & Goldenberg, C. (Eds). *Language and literacy development in bilingual settings.* New York: Guilford Press.

Bialystok, E., & Martin, M. M. (2004). Attention and inhibition in bilingual children: Evidence from the Dimensional Change Card Sort task. *Developmental Science, 7,* 325-339.

Bialystok, E., Martin, M. M., & Viswanathan, M. (2005). Bilingualism across the lifespan: The rise and fall of inhibitory control. *International Journal of Bilingualism, 9*, 103–119.

Bialystok, E., & Mitterer, J. (1987). Metalinguistic differences among three kinds of readers. *Journal of Educational Psychology, 79,* 147-153.

Bialystok, E., & Senman, L. (2004). Executive processes in Appearance-Reality tasks: The role of inhibition of attention and symbolic representation. *Child Development, 75,* 562-579.

Bialystok, E. & Shapero, D. (2005). Ambiguous benefits: the effect of bilingualism on reversing ambiguous figures. *Developmental Science, 8*, 595–604.

Bialystok, E. & Viswanathan, M. (2009). Components of executive control with advantages for bilingual children in two cultures. *Cognition, 112,* 494-500.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. S., & Cohen, J. D. (2001). Conflict monitoring and cognitive control. Psychological Review, 108, 624_652.

Bradley, R.H., & Corwyn, R.F. (2002) Socioeconomic status and child development. *Annu. Rev. Psychol. 53,* 371–399.

Braveman, P.A. et al. (2005) Socioeconomic status in health research: one size does not fit all. *Journal of the American Medical Association, 294,* 2879–2888.

Brown, N. A., Bown, J. & Eggett, D. L. (2009). Making rapid gains in second Language Writing: A Case Study of a Third-Year Russian language course.

Foreign Language Annals, 42, 424-452.

Bronson, M. B. (2002). *Self-regulation in early childhood: Nature and nurture.* New York: Guilford.

Buckner, J. C., Mezzacappa, E., & Beardslee, W. R. (2003). Characteristics of resilient youths living in poverty: The role of self-regulatory processes. *Development and Psychopathology,15,* 139 – 162.

Bunge, S. A., Hazeltine, E., Scanlon, M. D., Rosen, A. C., & Gabrieli, J. D. E. (2002). Dissociable contributions of prefrontal and parietal cortices to response selection. *Neuroimage, 17,* 1526-1571.

Callejas, A., Lupiáñez, J., Funes, M. J. & Tudela, P. (2005).Modulations among the alerting, orienting and executive control networks. Experimental Brain Research 167, 27– 37.

Callejas, A., Lupiáñez, J. & Tudela, P. (2004). The three attentional networks: On its independence and interactions. Brain and Cognition, 54, 225–227.

Campbell, D. E. (2010). *Choosing Democracy: A Practical Guide to Multicultural Education* (4th ed.). UK: Pearson Education Inc.

Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11,* 282-298.

Carlson, S.M., & Moses, L.J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development, 72,* 1032–1053.

Carlson, S.M., Moses, L.J., & Breton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development, 11*, 73–92.

Charness, N. (2008). Aging and Human Performance. *Human Factors, 50,* 548–555.

Chee, M.W.L., Soon, C.S., & Ling Lee, H. (2003). Common and segregated neuronal networks for different languages revealed using functional magnetic resonance adaptation. *Journal of Cognitive Neuroscience, 15,* 85–97.

Chen, X., Hastings, P.D., Rubin, K.H., Chen, H., Cen, G., & Stewart, S.L. (1998). Child-rearing attitudes and behavioral inhibition in Chinese and Canadian toddlers: A cross-cultural study. *Developmental Psychology, 34,* 677–686.

Colome´, A. (2001). Lexical activation in bilinguals' speech production: Language-specific or language independent? *Journal of Memory and Language, 45,* 721-736.

Colzato, L. S., Bajo, M. T., van den Wildenberg, W., & Paolieri, D. (2008). How does bilingualism improve executive control? A comparison of active and reactive inhibition mechanisms. Journal of Experimental Psychology: Learning, Memory and Cognition, 34, 302-312.

Conger, R.D., Ge, X., Elder, G.H., Lorenz, F.O., & Simons, R.L. (1994). Economic stress, coercive family process, and developmental problems of adolescents. *Child Development, 65,* 541–561.

Conger, R.D., Patterson, G.R., & Ge, X. (1995). It takes two to replicate: a mediational model for the impact of parents' stress on adolescent adjustment. *Child Development, 66,* 80– 97.

Connelly, S. L., Hasher, L., & Zacks, R. T. (1991). Age and reading: The impact of distraction. Psychology and Aging, 6, 533–541.

Costa, A. (2005). Lexical access in bilingual production. In J. F. Kroll & A. M. B. De Groot (Eds.), *Handbook of bilingualism: psycholinguistic approaches* (pp. 308-

325). New York: Oxford University Press.

Costa, A., & Caramazza, A. (1999). Is lexical selection in bilinguals language-specific? Further evidence from Spanish-English bilinguals and English-Spanish bilinguals. *Bilingualism: Language and Cognition, 2*, 231-244.

Costa, A., Hernández, M., Costa-Faidella, J., & Sebastián-Gallés, J. (2009). On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition, 113*, 135-149.

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition, 106*, 59-86.

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language, 41*, 365–397.

Costa, A., & Santesteban, M. (2004b). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language, 50*, 491-511.

Costa, A., Santesteban, M., & Ivanova, I. (2006). How do highly-proficient bilinguals control their lexicalization process? Inhibitory and language-specific selection mechanisms are both functional. *Journal of Experimental Psychology: Learning, Memory and Cognition, 32,* 1057-1074.

Craik, F. I. M., & Bialystok, E. (2006). Cognition through the lifespan: mechanisms of change. *Trends in Cognitive Science, 10,* 131-138.

Craik, F. I. M., & Grady, C. L. (2002). Aging, memory and frontal lobe functioning. In D.T. Stuss & R.T. Knight (Eds.), *Principles of frontal lobe function* (pp. 528–

540). New York: Oxford University Press.

Cramer, D. & Howitt, D. L. (2005). *The SAGE Dictionary of Statistics: A Practical Resource for Students in the Social Sciences* (Third ed.). UK, London: Sage.

Cromdal, J. (1999). Childhood bilingualism and metalinguistic skills: Analysis and control in young Swedish–English bilinguals. Applied Psycholinguistics, 20, 1–20.

Cummins, J. (1976). The influence of bilingualism on cognitive growth: a synthesis of research findings and explanatory hypotheses. *Working Papers on Bilingualism, 9,* 1–43.

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology, 19,* 294-304.

Deary, I. J., & Der, G. (2005b). Reaction time, age and cognitive ability: Longitudinal findings from age 16 to 63 years in representative population samples. Aging Neuroscience and Cognition, 12, 187–215.

De Bot, K. (1992). A bilingual production model: Levelt's "speaking" model adapted. *Applied Linguistics, 13,* 1–24.

Delgado, P., Guerrero, G., Goggin, J. P., & Ellis, B. B. (1999). Self-assessment of linguistic skills by bilingual Hispanics. *Hispanic Journal of Behavioral Sciences, 21,* 31-46.

De Neys, W. & W. Schaeken (2007). When people are more logical under cognitive load: Dual task impact on scalar implicature. *Experimental Psychology 54,* 128-133.

Der, G., & Deary, I. J. (2006). Age and Sex Differences in Reaction Time in Adulthood: Results From the United Kingdom Health and Lifestyle Survey.

Psychology and Aging, *21*, 62-73.

Désert, M., Préaux, M., & Jund, R. (2009). So young and already victims of stereotype threat: Socio-economic status and performance of 6 to 9 years old children on Raven's progressive matrices. *European Journal of Psychology of Education*, *24*, 207-218.

Dewaele, J. M. (2001). Activation or inhibition? The interaction of L1, L2 and L3 on the language mode continuum. In J. Cenoz, B. Hufeisen, & U. Jessner (Eds.), *Cross-linguistic influence in third language acquisition: Psycholinguistic perspectives (pp. 69–89).*

Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D.T. Stuss & R.T. Knight (Eds.), *Principles of frontal lobe function* (pp. 466–503). New York: Oxford University Press.

Duncan, O. D. (1961). Asocioeconomic indexfor all occupations. In: Reiss, A. J. Jr, Duncan, O. D., Hatt, P. K. & North, C. C. (eds.). *Occupation and Social Status.* New York: The Free Press of Glencoe.

Duncan, G.J. & Magnuson, K.A. (2003). Off with Hollingshead: socioeconomic resources, parenting, and child development. In Bornstein, M.H. and Bradley, R.H., (Eds), *Socioeconomic Status, Parenting, and Child Development* (pp. 83–106), Lawrence Erlbaum Associates.

Duncan, J., & Owen, A. M. (2000). Common regions of the human frontal lobe recruited by diverse cognitive demands. *Trends in Neuroscience*, *23*, 475-483.

Economou, A. & Nikolaou, A. (2005). Socio-economic inequalities in health: A review of the Greek evidence. *Spoudai, 55,* 74-88 (in Greek).

Eupedia (2012). Retrieved 14 September, 2012, from http://www.eupedia.com/forum/showthread.php?26956-Map-of-Individualism-%28vs-Collectivism%29

Fan, J., McCandliss, B. D., Flombaum, J. I., & Posner, M. (2001). *Imaging attentional networks.* Paper presented at the Annual Meeting of the Society for Neuroscience, San Diego, CA.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14,* 340–347.

Fan, J., Wu, Y., Fossella, J. A., & Posner, M. I. (2001). Assessing the heritability of attentional networks. *BMC Neuroscience, 2,* 14.

Farah, M.J., & Noble, K.G. (2005). Socio-economic influences on brain development: a preliminary study. In U. Mayr, E. Awh, & S.W. Keele (Eds.), *Developing individuality in the human brain: A tribute to Michael Posner* (pp. 189–208). Washington, DC: APA.

Fernandes, M. A., Craik, F., Bialystok, E., & Kreuger, S. (2007).Effects of bilingualism, aging and semantic relatedness on memory under divided attention. Canadian Journal of Experimental Psychology, 61, 128-141.

Festman, J., Rodriguez-Fornells, A., & Münte, T. F. (2010). Individual differences in control of language interference in late bilinguals are mainly related to general executive abilities. *Behavior and Brain Functions, 6.*

Finkbeiner, M., Golla, T. H. & Caramazza, A. (2006). Lexical access in bilingual speakers: What's the (hard) problem? *Bilingualism: Language and Cognition, 9,* 153-166.

Fossella, J., Posner, M. I., Fan, J., Swanson, J. M., & Pfaff, D. W. (2002). Attentional phenotypes for the analysis of higher mental function. *ScientificWorld Journal, 2,* 217–223.

Fossella, J., Sommer, T., Fan, J., Wu, Y., Swanson, J. M., Pfaff, D. W., et al. (2002). Assessing the molecular genetics of attention networks. *BMC Neuroscience, 3,* 14.

Fozard, J. L., Vercruyssen, M., Reynolds, S. L., Hancock, P. A., & Quilter, R. E. (1994). Age differences and changes in reaction time: The Baltimore Longitudinal Study of Aging. *Journal of Gerontology: Psychological Sciences, 49,* 179–189.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General, 133,* 101-135.

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive Development, 10,* 483-527.

Fuentes, L. J., & Campoy, G. (2008). The time course of alerting effect over orienting in the attention network test. *Experimental Brain Research, 185,* 667-672.

Fuentes, L. J., Vivas, A. B., Langley, L. K., Chen, Q., & Gonzalez-Salinas, C. (2011). Inhibitory mechanisms in the attentional networks: A multidisciplinary approach. In M. I. Posner (Ed.), Cognitive neuroscience of attention (2nd ed.).

Fujishiro, K., Xu, J., & Gong, F. (2010). What does "occupation" represent as an indicator of socioeconomic status?: Exploring occupational prestige and health. *Social Science & Medicine, 71,* 2100-2107.

Garnham, A. (1985). *Psycholinguistics. Central topics.* London: Methuen.

Garratt, L. C., & Kelly, T. P. (2008). To what extent does bilingualism affect children's performance on the NEPSY? Child Neuropsychology, 14, 71-81.

Gathercole, V. C. M., Thomas, E. M., Jones, L., Guasch, N. V., Young, N. & Hughes, E. K. (2010). Cognitive effects of bilingualism: digging deeper for the contributions of language dominance, linguistic knowledge, socio-economic status and cognitive abilities. *International Journal of Bilingual Education and Bilingualism*, 13, 617-664.

Geurts, B. (2010). *Quantity Implicature.* Cambridge, UK: Cambridge University Press.

Glick, J. E., Bates,L., & Yabiku, S. T. (2009). Mother's age at arrival in the United States and early cognitive development. *Early Childhood Research Quarterly, 24,* 367–380.

Gollan, T. H., & Acenas, L. A. (2000, April).*Tip-of-the-tongue incidence in Spanish-English and Tagalog-English bilinguals.* Paper presented at the Third International Symposium on Bilingualism, Bristol, U.K.

Gollan, T. H., Fennema-Notestine, C., Montoya, R. I., & Jernigan, T. L. (2007). The bilingual effect on Boston Naming Test performance. *The Journal of the International Neuropsychological Society, 13,* 197–208.

Gollan, T. H., Montoya, R. I., & Werner, G. A. (2002). Semantic and letter fluency in Spanish–English bilinguals. *Neuropsychology, 16,* 562–576.

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition, 1,* 67–81.

Grice, H. P. (1989). *Studies in the way of words.* Cambridge, MA: Harvard University

Press.

Grosjean, F. (1997). Processing mixed languages: Issues, findings and models. In de A. M. B. de Groot & J. F. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 225–254). Mahwah, NJ: Erlbaum.

Guasti, M. T., Chierchia, G., Crain, S., Foppolo, F., Gualmini, A., & Meroni, L. (2005). Why children and adults sometimes (but not always) compute implicatures. *Language and Cognitive Processes, 20,* 667 –696.

Hackman, D. A. & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences, 13,* 65-73.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), The psychology of learning and motivation (Vol. 22, pp. 193–225). New York: Academic Press.

Hernandez, A.E. (2009). Language switching in the bilingual brain: What's next? *Brain & Language*, *109,* 133–140.

Hernández, M., Costa, A., Fuentes, L. J., Vivas, A. B., & Sebastián-Gallés, N. (2010). The impact of bilingualism on the executive control and orienting Networks of attention. *Bilingualism: Language and Cognition, 13*, 315-325.

Hernandez, A.E., Dapretto, M., & Bookheimer, S. (2001). Language switching and language representation in Spanish-English bilinguals: An fMRI study. *NeuroImage, 14,* 510–520.

Hernandez, A. E., Martinez, A., & Kohnert, K. (2000). In search of the language switch: An fMRI study of picture naming in Spanish_English bilinguals. *Brain and Language, 73,* 421-431.

Hietanen, J.K., 1999. Does your gaze direction and head orientation shift my visual attention? *NeuroReport 10,* 3443–3447.

Ho, D.Y.F. (1994). Cognitive socialization in Confucian heritage cultures. In P.M. Greenfield & R.R. Cocking (Eds.), *Cross-cultural roots of minority development* (pp. 285–313). Hillsdale, NJ: Erlbaum.

Hollingshead, A. B. (1971). The indiscriminate state of social class measurement. *Soc. Forces, 49,* 563-567.

Holm, H. J. (2010). A possible homeland of the Indo-European languages and their migrations in the light of the Separation Level Recovery (SLRD) method. Retrieved 13 November 2012, from http://www.hjholm.de/

Hornberger, N. H. (1990). Bilingual education and English-only: A language planning framework. *The Annals of the American Academy of Political and Social Sciences, 508,* 12-26.

Ivanova, I. & Costa, A. (2008). Does bilingualism hamper lexical access in speech production? *Acta Psychologica, 127,* 277–288.

Katsos, N. (2009). Neither default nor particularised: Scalar implicature from a developmental perspective. In U. Sauerland, K. Yatsushiro (Eds.), *Experimental semantics and pragmatics, Palgrave studies in pragmatics, language & cognition* (pp. 51–73).

Katsos, N., & Bishop, D. V. M. (2011). Pragmatic tolerance: Implications for the acquisition of informativeness and implicature. *Cognition, 120,* 67-81.

Kerns, J. G., Cohen, J. D., MacDonald, A. W., Cho, R.Y., Stener, V. A., Carter, C. S. (2004). Anterior cingulated conflict monitoring and adjustments in control.

Science, *303,*1023–1026.

Kharkhurin, A. V. (2010). Bilingual verbal and nonverbal creative behavior. *International Journal of Bilingualism, 14,* 211-226.

Kochanska, G., Murray, K.T., & Harlan, E.T. (2000). Effortful control in early childhood: continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36,* 220–232.

Kolers, P. A., & Paradis, M. (1980). Psychological and linguistic studies of bilingualism. *Canadian Journal of Psychology, 34*, 287-303.

Koulakoglou, K. (1998). *Psychometrics and Psychological Evaluation.* Athens: Papazisi.

Kouri, N., Petridou, E., Skalkidis, Y., Revinthi, K. & Trichopoulos, D. (1995). School injuries in relation to socio-economic and familial risk, *Iatriki, 68*, 603-608 (in Greek).

Krieger, N. et al. (1997). Measuring social class in U.S. public health research: concepts, methodologies, and guidelines. *Annual Review of Public Health, 18,* 341–378.

Kroll, J. F., Bobb, S. C., Misra, M., Guo, T. (2008). Language selection in bilingual speech: Evidence for inhibitory processes. *Acta Psychologica*, *128*, 416–430.

Kroll, J. F., Bobb, C. & Wodniecka, Z. (2006). Language selectivity is the exception, not the rule: Argument against the fixed locus of language selection in bilingual speech. *Bilingualism: Language and Cognition, 4, 233-248.*

Kyriopoulos, J., Gregory, S. & Economou, X. (2002). *Health and health services in the Greek population.* National School of Public Health, Department of Health

Economics, Athens.

Landry, R. G. (1974). A comparison of second language learners and monolinguals on divergent thinking tasks at the elementary school level. *The Modern Language Journal, 58,* 10-15.

Landry, S.H., & Chapieski, M.L. (1989). Joint attention and infant toy exploration: effects of Down syndrome and prematurity. *Child Development, 60,* 103–118.

Lansbergen, M. M, Kenemans, J. L , van Engeland, H. (2007). Stroop interference and attention-deficit/hyperactivity disorder: a review and meta-analysis. *Neuropsychology, 21,* 251–62.

Laskari, H., Kotsonis, K., Velentzas, M., Liakopoulou, M. & Tsitoura, S. (2000). Stress, anxiety, depression and job satisfaction among groups of health service staff. *Paediatriki, 63,* 225-230 (in Greek).

Lavie, N., Hirst, A., De Fockert, J.W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General, 133,* 339–354.

Lee, M. W., & Williams, J. N. (2001). Lexical access in spoken word production by bilinguals: Evidence from the semantic competitor priming paradigm. Bilingualism: Language and Cognition, 4, 233–248.

Levy, B.J., McVeigh, N.D., Marful, A., & Anderson, M.C. (2007). Inhibiting your native language: The role of retrieval-induced forgetting during second language acquisition. *Psychological Science, 18,* 29–34.

Linver, M.R., Brooks-Gunn, J., & Kohen, D.E. (2002). Family processes as pathways from income to young children's development. *Developmental Psychology, 38,* 719–734.

Lipina, S. J. & Colombo, J. A. (2009). *Poverty and Brain Development During Childhood: An Approach from Cognitive Psychology and Neuroscience.* U.S.A.: American Psychological Association

Liston, C., Matalon, S., Hare, T. A., Davidson, M. C. & Casey, B. J. (2006). Anterior cingulate and posterior parietal cortices are sensitive to dissociable forms of conflict in a task switching paradigm. *Neuron, 50,* 643–653.

Liston, C., McEwen, B. S., & Casey, B. J. (2009). Psychosocial stress reversibly disrupts prefrontal processing and attentional control. *Proceedings of the National Academy of Sciences of the United States of America (PNAS), 106,* 912-917.

Logan, G. D. (1995). Linguistic and conceptual control of visual spatial attention. *Cognitive Psychology, 28,* 103-174.

Luks, T. L., Oliveira, M., Possin, K. L., Bird, A., Miller, B. H., Weiner, m. W. et al. (2010). Atrophy in two attention networks is associated with performance on a Flanker task in neurodegenerative disease. *Neuropsychologia, 48,* 165–170.

Luks, T. L., Simpson, G.V., Dale, C. L. & Hough, M. G. (2007). Preparatory allocation of attention and adjustments in conflict processing. *Neuroimage* , 949–58.

Lynn, R. (2003). The Geography of Intelligence. *The Scientific Study of General Intelligence: Tribute to Arthur R. Jensen.* London: Elsevier Science Ltd.

MacLeod CM (1991). "Half a century of research on the Stroop effect: an integrative review". *Psychological bulletin, 109,* 163–203.

Madianos, M. G. & Stefanis, C. N. (1992). Changes in the prevalence of symptoms of depression and depression across Greece. *Social Psychiatry and Psychiatric Epidemiology, 27*, 211-219.

Magnuson, K. A. & Duncan, G. J. (2006). The role of family socioeconomic resources in the black–white test score gap among young children. *Developmental Review, 26,* 365–399.

Mallory, J. P. & Adams, D. Q. (2006). *The Oxford Introduction to Proto-Indo-European and the Proto-Indo-European World.* N. Y.: Oxford University Press.

Markus, H. & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion and motivation. *Psychological Review 98*(2):224–53.

Martin, G. N. (2006). Human neuropsychology (2nd ed.). England: Pearson Education. Martin-Rhee, M. M., & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition, 11*, 81–93.

Martin-Rhee, M. M. & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition*, 11, 1–13.

Mayr, U. (2003). Towards principles of executive control: how mental sets are selected. In: Kluwe, R.H., Luer, G., Rosler, F. (Eds.), *Principles of Learning and Memory, vol. 1.* Birkhauser Verlag, Basel, Switzerland, pp. 223– 241.

Mayr, U. & Keele, S.W. (2000). Changing internal constraints on action: the role of backward inhibition. J. Exp. Psychol. Gen. 129 (1), 4 – 26.

McDowd, J. M., & Shaw, R.J. (2000). Attention and aging: A functional perspective.

In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition, Second Edition* (pp.221 – 292). Mahwah, NJ; Erlbaum.

Mergoupis, T. (2001). Access to health care in Greece: a micro-level analysis. First Conference of the Hellenic Social Policy Association, Democritus University of Thrace, Komotini.

Meuter, R. F. I. & Allport, A. (1999). Bilingual language switching in naming: Asymmetrical costs of language selection. *Journal of Memory and Language, 40,* 25-40.

Meuter, R. F. I. & Simmond, M. (2007). *The aging bilingual and executive function: Beyond the Simon effect.* Poster presented at the 6th International Symposium on Bilingualism, May 30th – June 2nd, 2007, University of Hamburg.

Mezzacappa, E. (2004). Alerting, orienting, and executive attention: developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children. *Child Development, 75,* 1373–1386.

Mindt, M. R., Arentoft, A., Germano, K. K., D'Aquila, E., Scheiner, D., Pizzirusso, M. et al. (2008). Neuropsychological, cognitive, and theoretical considerations for evaluation of bilingual individuals. *Neuropsychological Reviews, 18,* 255-268.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology, 41,* 49–100.

Morales, M., Mundy, P., Crowson, M. M., Neal, R. A., & Delgado, C. E. F. (2005). Individual differences in infant attention skills, joint attention and emotion regulation behavior. *International Journal of Behavioral Development, 29,* 259-263.

Morton, J. B. & Harper, S. N. (2007). What did Saymon say? Revisiting the bilingual advantage. *Developmental Science, 10,* 719-726.

Moscovitch, M., & Winocur, G. (1992). The neuropsychology of memory and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), The handbook of aging and cognition (pp. 315–372). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Mueller, C. W. & Parcel, T. L. (1981). Measures of socioeconomic status: alternatives and recommendations. *Child Development, 52,* 13-30.

Najman, J. A., Airda, R., Borb, W., O'Callaghan, M., Williams, G., Shuttlewooda, G. J. (2004). The generational transmission of socioeconomic inequalities in child cognitive development and emotional health. *Social Science and Medicine, 58,* 1147–1158.

Nardone, R., De Blasi, P., Bergmannd, J., Caleri, F., Tezzonb, F., Ladurnerd, G., Golaszewskia, S., & Trinka, E. (2011). Theta burst stimulation of dorsolateral prefrontal cortex modulates pathological language switching: A case report. *Neuroscience Letters, 487,* 378-382.

Nassauer, K. W., & Halperin, J. M. (2003). Dissociation of perceptual and motor inhibition processes through the use of novel computerized conflict tasks. *Journal of the International Neuropsychological Society, 9,* 25–30.

Nasreddine, Z.S., Phillips, N.A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I.et al. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for Mild Cognitive Impairment. *Journal of the American Geriatrics*

Society, 53, 695-699.

National Institute of Child Health and Human Development and Early Child Care Research Network. (2002). The Relation of Global First-Grade Classroom Environment to Structural Classroom Features and Teacher and Student Behaviors. *The Elementary School Journal, 102*, 367.

Natsiopoulou, T., & Melissa-Halikiopoulou, C. (2009). Effects of socioeconomic status on television viewing conditions of preschoolers in northern Greece. *Early Child Development and Care, 179,* 407-423.

Nazem, S., Siderowf, A. D., Duda, J. E., Have, T. T., Colcher, A., Horn, S. S. et al., (2009). Montreal Cognitive Assessment performance in patients with Parkinson's Disease with ''normal'' global cognition according to Mini-Mental State Examination score. *Journal of the American Geriatrics Society, 57,* 304-308.

NICHD, National Institute of Child Health and Human Development Early Child Care Research Network, (2003). Do children's attention processes mediate the link between family predictors and school readiness? *Developmental Psychology, 39,* 581 – 593.

Nicoladis, E., & Genesee, F. (1997). Language development in preschool bilingual children. *Journal of Speech-Language Pathology and Audiology, 21,* 258–270.

Nicoladis, E., & Giovanni, S. (2000). The role of a child's productive vocabulary in the language choice of a bilingual family. *First Language, 20,* 3–28.

Noble, K.G. et al. (2005) Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Sciences, 8,* 74–87.

Papafragou, A., & Musolino, J. (2003). Scalar implicatures: experiments at the semantics-pragmatics interface. *Cognition, 86,* 253-282.

Paradis, M. (1989). Bilingual and polyglot aphasia. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology* (pp. 117–140). Amsterdam: Elsevier.

Périn, B., Godefroy, O., Fall, S. & de Marco, G. (2010). Alertness in young healthy subjects: An fMRI study of brain region interactivity enhanced by a warning signal. *Brain and Cognition 72*, 271–281.

Petridou, E., Kosmidis, H., Haidas, S., Tong, D., Revinthi, K., Flytzani, V., et al. (1994). Survival from childhood leukemia depending on socio-economic status in Athens. *Oncology, 51,* 391-395.

Petridou, E., Kouri, N., Trichopoulos, D., Revinthi, K., Skalkidis, Y. & Tong, D. (1994). School injuries in Athens: Socioeconomic and family risk factors. *Journal of Epidemiology and Community Health, 48*, 490-491.

Petridou, E., Malamou, E., Doxiadis, S., Pantelakis, S., Kanelopoulou, G., Toupadaki, et al. (1995). Blood lipids in Greek adolescents and their relation to diet, obesity, and socio-economic factors. *Annals of Epidemiology, 5*, 286-291.

Petridou, E., Polychronopoulou, A., Dounis, E., Tsampira, P., Revinthi, K. & Trichopoulos, D. (1996). Risk factors for injuries among the elderly in Greece. *Accidents Annals and Prevention, 28,* 333-338.

Petridou, E., Zavitsanos, X., Dessypris, N., Frangakis, C., Mandyla, M., Doxiadis, S. et al. (1997). Adolescents in high-risk trajectory: Clustering of risky behavior and the origins of socio-economic health differentials. *Preventive Medicine, 26*, 215-219.

Philipp, A.M. & Koch, I. (2009). Inhibition in language switching: What is inhibited when switching between languages in naming tasks? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35,* 1187–1195.

Philipp, A. M., Gade, M., & Koch, I. (2007). Inhibitory processes in language switching: Evidence from switching language-defined response sets. European *Journal of Cognitive Psychology, 19,* 395-416.

Porter, R. P. (1990). *Forked tongue: The politics of bilingual education*. New York: Basic Books.

Portocarrero, J. S., Burrightm, R. G., & Donovick, P. J. (2007). Vocabulary and verbal fluency of bilingual and monolingual college students. *Archives of Clinical Neuropsychology, 22*, 415-422.

Posner, M. I. (1978). *Chronometric Explorations of the Mind.* Hillsdale, L. J.: Lawrence Elbaum Associates.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology, 32*, 3–25.

Posner, M. I. & Boies, S. J. (1971). Components of attention. *Psychological Review, 78,* 391-408.

Posner, M.I., & Cohen, Y. (1984). Components of performance. In H. Bouma & D. Bowhuis (eds) *Attention and Performance X.* Hillsdale, NJ: Erlbaum (pp. 531-556).

Posner, M. I., & Petersen, S. E. (1990). The attention systems of the human brain. *Annual Review of Neuroscience, 1*3, 25–42.

Poulin-Dubois, D., Blaye, A., Coutya, J., & Bialystok, E. (2011). The effects of bilingualism on toddlers' executive functioning. *Journal of experimental Child*

Psychology, 108, 567-579.

Poulisse, N. (1999). *Slips of the tongue: Speech errors in first and second language production.* Amsterdam, The Netherlands: Benjamins.

Poulisse, N., & Bongaerts, T. (1994). First language use in second language production. Applied Linguistics, 15, 36–57.

Pujol J, Vendrell P, Deus J, et al. (2001). The effect of medial frontal and posterior parietal demyelinating lesions on stroop interference. *NeuroImage, 13,* 68–75.

Raven, J. C. (1958). *The Standard Progressive Matrices.* London: H. K. Lewis.

Raven, J. C. (2000). The Raven's Progressive Matrices: Change and stability over culture and time. *Cognitive Psychology, 41,* 1-48.

Raven, J.C., Court, J.H. & Raven, J.C. (1990). *Manual for Raven's Progressive Matrices and Vocabulary Scales - Section 2: Coloured Progressive Matrices.* Oxford: Oxford Psychologists Press.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception and Performance, 18,* 849–860.

Raz, N. (2000). Aging of the brain and its impact on cognitive performance: Integration of structural and functional findings. In F.I.M. Craik & T.A. Salthouse (Eds.), *The handbook of aging and cognition* (2nd ed., pp. 1–90). Mahwah, NJ: Erlbaum.

Reber, A. S., & Reber, E. S. (2001). *Dictionary of psychology* (3rd ed.). London:

Penguin Group.

Rindermann, H., Flores-Mendoza, C., & Mansur-Alves, M. (2010). Reciprocal effects between fluid and crystallized intelligence and their dependence on parents' socioeconomic status and education. *Learning and Individual Differences, 20,* 544–548.

Robertson, I. H., Tegner, R., Tham, K., Lo, A., & Nimmo-Smith, I. (1995). Sustained attention training for unilateral neglect: Theoretical and rehabilitation implications. *Journal of Clinical and Experimental Neuropsychology, 17,* 416–430.

Rodriguez-Fornells, A., Rotte, M., Heinze, H.J. , Nösselt, T., & Münte, T.F. (2002). Brain potential and functional MRI evidence for how to handle two languages with one brain, *Nature, 415,* 1026–1029.

Rosselli, M., Arlida, A., Araujo, K., Weekes, V. A., Caracciolo, V., Padilla,M., et al. (2000). Verbal fluency and repetition skills in healthy older Spanish–English bilinguals. *Applied Neuropsychology, 7,* 17–24.

Rougier, N.P., O'Reilly, R.C., 2002. Learning representations in a gated prefrontal cortex model of dynamic task switching. *Cogn. Sci. 26,* 503– 520.

Rowe, D. C., Jacobson, K. C., & Van den Oord, E. J. C. (1999). Genetic and environmental influences on Vocabulary IQ: Parental education level as a moderator. *Child Development, 70,* 1151-1162.

Rueda, M. R. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P. et al. (2004). Development of attentional networks in childhood. *Neuropsychologia, 42,* 1029–1040.

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). Training, maturation, and genetic influences on the development of executive attention. *PNAS, 102,* 14931-14936.

Ruz, M. & Lupi´a˜nez, J. (2002). A review of Attentional Capture: On its automaticity to endogenous control. *Psicol´ogica, 23*, 283–309.

Rypma, B., & D'Esposito, M. (2000). Isolating the neural mechanisms of age-related changes in human working memory. *Nature neuroscience, 3,* 509-515.

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and Theory of Mind. *Psychological Science, 17*, 74-81.

Sandoval, T.C. (2010). *The Role of Control in Bilingual Verbal Fluency: Evidence From Aging and Alzheimer's Disease.* Unpublished doctoral dissertation, University of California, San Diego/ San Diego State University.

Sebastián-Gallés, N. & Bosch, L. (2001). On Becoming and Being Bilingual. In E. Dupoux (Ed.), *Language, Brain, and Cognitive Development: Essays in Honor of Jacques Mehler* (pp. 379-393). Massachusetts: The MIT Press.

Secada, W. G. (1990). Research, politics, and bilingual education. *The Annals of the American Academy of Political and Social Sciences, 508,* 81-106.

Segalowitz, N., & Frenkiel-Fishman, S. (2005). Attention control and ability level in a complex cognitive skill: attention shifting and second-language proficiency. *Memory & cognition, 33,* 644-53.

Siegal, M., Iozzi, L. & Surian, L. (2009). Bilingualism and conversational understanding young children. *Cognition 110,* 115–22.

Siegal, M., Matsuo, A., & Pond, C. (2007). Bilingualism and cognitive development: Evidence from scalar implicatures. In Y. Otsu (Ed.), *Proceedings of the Eighth Tokyo Conference on Psycholinguistics* (pp. 265-280). Tokcesses in the frontal lobes. *Science, 283*, 1657-1661.

Siegal, M., & Surian, L. (2008) Conversational Understanding in Young Children. In E. Hoff and M. Shatz (Eds.), *Blackwell Handbook of Language Development,* Blackwell Publishing Ltd, Oxford, UK.

Siegal, M., Surian, L., Matsuo, A., Geraci, A., Iozzi, L., Okumura, Y. et al. (2010). Bilingualism accentuates children's conversational understanding. *PlosOne, 5,* 1-8.

Simon, J. R. & Rudell, A. P. (1967). Auditory S-R compatibility: the effect of an irrelevant cue on information processing. Journal of applied psychology, 51, 300-304.

Singh-Manoux, A. et al. (2005). Socioeconomic position across the lifecourse: how does it relate to cognitive function in mid-life? *Annals of Epidemiology, 15,* 572–578.

does it relate to cognitive function in mid-life? *Ann. Epidemiol. 15,* 572–578.

Slabakova, R. (2009). Scalar implicatures in second language acquisition. *Lingua, 120*, 2444-2462.

Smith, E. E. & Jonides, J. (1999).Storage and executive processes in the frontal lobes. *Science, 283,* 1657-1661.

Statistics Canada. (2003a). Education indicators in Canada: report of the Pan-Canadian education indicators programme. *Catalogue no. 81-582-XPE*. Ottawa, ON: Canada. Authority of the Minister Responsible for Statistics Canada, Toronto.

Stroop, John Ridley (1935). "Studies of interference in serial verbal reactions". *Journal of Experimental Psychology 18*, 643–662.

Sturm, W., & Willmes, K. (2001). On the Functional Neuroanatomy of Intrinsic and Phasic Alertness. *NeuroImage 14,* S76–S84.

Surian, L., Tedodli, M., & Siegal, M. (2010). Sensitivity to conversational maxims in deaf and hearing children. *Journal of Child Language, 37,* 929-943.

Thimm, M., Fink, G. R., Kust, J., Karbe, H., & Sturm, W. (2006). Impact of alertness training on spatial neglect: A behavioural and fMRI study. *Neuropsychologia, 44,* 1230–1246.

Treccani, B., Argyri, E., Sorace, A., & Sala, S. D. (2009). Spatial negative priming in bilingualism. *Psychonomic Bulletin & Review, 16,* 320-327.

Tipper, S. P., Weaver, B., Cameron, S., Brehaut, J. C., & Bastedo, J. (1991). Inhibitory mechanisms of attention in identification and localization tasks: Time course and disruption. *Journal of Experimental Psychology, 17*, 681-692.

Turrell, G. et al. (2002) Socioeconomic position across the lifecourse and cognitive function in late middle age. *J. Gerontol. Series B 57,* S43–S51.

Umbel, V.M., Pearson, B.Z., Fernandez, M.C., & Oller, D.K. (1992). Measuring bilingual children's receptive vocabularies. *Child Development, 63*, 1012–1020.

Vandenbossche, J., Deroost, N., Soetens, E., Zeischka, P., Spildooren, J., Vercruysse, S. et al. (2012). Conflict and freezing of gait in Parkinson's disease: support for a response control deficit. *Neuriscience, 206*, 144-154.

Van der Linden, M., Bredart, S. & Beerten, A. (1994). Age-related differences in updating working memory. *British Journal of Psychology, 85,* 145–151.

van Heuven, W. J. B., Schriefers, H., Dijkstra, T. & Hagoort, P. (2008). Language conflict in the bilingual brain. *Cerebral Cortex, 18,* 2706–2716.

van Maanen, L., van Rijn, H., & Borst, J. P. (2009). Stroop and picture-word interference are two sides of the same coin. *Psychological Bulletin Reviews, 16,* 987–99.

Verhaeghen, P., & De Meersman, L. D. (1998). Aging and the Stroop Effect: A Meta-analysis. *Psychology and Aging, 13,* 120-126.

Vivas, A. B., Humphreys, G. W. & Fuentes, L. J. (2003). Inhibitory processing following damage to the parietal lobe. *Neuropsychologia, 41,* 1531-1540.

Walker, A. J., Batchelor, J., & Shores, A. (2009). Effects of education and cultural background on performance on WAISIII, WMS-III, WAIS-R and WMS-R measures: Systematic review. *Australian Psychologist, 44,* 216–223.

Wang, Y., Xue, G., Chen, C., Xue, F., & Donga, Q. (2007). Neural bases of asymmetric language switching in second-language learners: An ER-fMRI study. *Neuroimage, 35,* 862-870.

Wasserman, G. A., Liu, X., Popovac, D., Factor-Litvak, p., Kline, J., Waternaux, C. et al. (2000). The Yugoslavia Prospective Lead study: Contributions of prenatal and postnatal lead exposure to early intelligence. Neurotoxicology and Teratology, 22, 811-818.

Wechsler, D. (1991). *The Wechsler intelligence scale for children—third edition.* San Antonio, TX: The Psychological Corporation.

Weissman, D. H., Warner, L. M., & Woldorff, M. G. (2004). The neural mechanisms for minimizing cross-modal distraction. *Journal of Neuroscience, 24,* 10941–9.

Wicherts, J. M., Dolan, C. V., Carlson, J. S., van der Maas, H. L. J. (2010). Raven's test performance of sub-Saharan Africans: Average performance, psychometric properties, and the Flynn Effect. *Learning and Individual Differences.*

Wu, D.Y.H. (1996). Chinese childhood socialization. In M.H. Bond (Ed.), *The handbook of Chinese psychology* (pp. 143–151). New York: Oxford University Press.

Xidea-Kikemeni, A., Aloumanis, P., Georgiou, Z. & Ktenas, E. (2005). Morbidity in workers in construction services. *Elliniki Iatriki Epitheorisi* (in Greek).

Zacks, R. T., Hasher, L.,& Li, K. Z. H. (2000). Human memory. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (2nd ed., pp. 293–357). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Zelazo, P.D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development, 11,* 37–63.

Zelazo, P.D., Jacques, S., Burack, J., & Frye, D. (2002). The relation between theory of mind and rule use: evidence from persons with autism-spectrum disorders. *Infant and Child Development, 11,* 171–195.

Zelazo, P. D., Müller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. Monographs of the Society for Research on *Child Development, 68,* vii-137.

Zied, K. M., Phillipe, A., Karine, P., Valerie, H. T., Ghislaine, A., Arnaud, R., et al. (2004). Bilingualism and adult differences in inhibitory mechanisms: Evidence from a bilingual Stroop task. *Brain and Cognition, 54,* 254-256.

Zimmermann, M. B., Connolly, K., Bozo, M., Bridson, J., Rohner, F. & Grimci, L.

(2006). Iodine supplementation improves cognition in iodine-deficient schoolchildren in Albania: a randomized, controlled, double-blind study. American Journal of Clinical Nutrition, 83, 108-114.

7. Appendices

7.1 Appendix A:

Instructions on the ANT.

This is an experiment investigating attention. You will be shown an arrow on the screen pointing either to the left or to the right (for example -> or <-). On some trials, the arrow will be flanked by two arrows to the left and two arrows to the right (for example ->->->->-> or ->-><-->->). Your task is to respond to the direction of the CENTRAL arrow. You should press the left mouse button with your left thumb if the central arrow points to the left or press the right mouse button with your right thumb if the central arrow points to the right.

Please make your response as quickly and accurately as possible. Your reaction time and accuracy will be recorded in milliseconds.

There will be a cross ("+") in the center of the screen and the arrows will appear either above or below the cross. You should try to fixate on the cross throughout the experiment.

On some trials there will be asterisk cues indicating when or where the arrow will occur. If the cue is at the center or both above and below fixation it indicates that the arrow will appear shortly. If the cue is only above or below fixation it indicates both that the trial will occur shortly and where it will occur. Try to maintain fixation at all times. However, you may attend when and where indicated by the cues.

The experiment contains four blocks. The first block is for practice and takes about two minutes. The other three blocks are experimental blocks and each takes about five minutes. After each block there will be a message "take a break" and you may take a short rest. After it, you can press the space bar to begin the next block. The whole experiment takes about twenty minutes.

If you have any question, please ask the experimenter. Press SPACE bar to start the practice trials.

7.2 Appendix B:

Adult Consent Form.

PARTICIPATION CONSENT FORM

Research Project: The attention processes of adults bilingual in Albanian and Greek.

Researcher: Aristea K. Ladas, PhD candidate

Affiliation: South East European Research Centre

Supervisors: Dr. A. B. Vivas; Professor M. Siegal

The researcher has fully explained this study to me, by means of the Information Sheet provided in the Research Envelope which I have read. I have had the opportunity to ask any questions and discuss my participation. Any questions have been answered to my satisfaction.

I agree to participate in this research project, and I understand that I am free to refrain from answering any question I do not wish to answer, or to withdraw from the study completely. I have been assured that I will not be penalized in any way for withholding information or withdrawing from the study, and that nobody other than the researcher and her supervisors will have access to the information.

I give my permission for results from the research to be used in the final report and in subsequent publication and/or presentation of results providing my identity is kept confidential.

Signature: ____

Name: ____

Date: _______________________

7.3 Appendix C:

Child Consent Form

PARENT PARTICIPATION CONSENT FORM

Research Project: The attention processes of children Albanian-Greek bilinguals.

Researcher: Aristea K. Ladas, PhD candidate

Affiliation: South East European Research Centre

Supervisors: Dr. A. B. Vivas; Professor M. Siegal

For Children/Minors (persons under 19 years of age) participating in this study, the term *You* addresses both the participant (the child: "you") and the parent or legally authorized representative ("your child").

Personal information relating to this study, including your name and age, as well as the data from the Questionnaire, may be shared with the researcher's supervisors and only with them.

By signing this informed consent, you automatically give your permission for results from the research to be used in the final report and in subsequent publication and/or presentation of results providing your identity is kept confidential.

Your taking part in this study is your choice. There will be no penalty if you decide not to be in the study. If you decide not to be in the study, you will not lose any benefits you are otherwise owed. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with this institution.

You are not waiving any of your legal rights by signing this informed consent document.

You have the right to request to see your data (how you performed on the experimental tasks). However, to ensure the scientific integrity of the research, you will not be able to review the research information until after you have completed all the research tasks.

You are making a decision whether or not to have your child participate in this study. Your signature indicates that you have read the information provided in the “Parent’s Information Sheet” and decided to allow your child to participate.

You will retain a copy of this signed informed consent document (included in the Research Envelope).

____Na
me of parent/parents or Legally Authorized Representative

____
Signature of Parent or Legally Authorized Representative

Date:________________

____Nam
e of researcher

____
Signature of Investigator

Date:_______________

IF YOUR CHILD IS ABLE TO SIGN, PLEASE COMPLETE THE FOLLOWING STATEMENT:

Assent of Child

_________________________(**first name** of child/minor) has agreed to participate in research titled “The attention processes of children and adult Albanian-Greek bilinguals.”

____
Signature Of Child

Date:_____________

OR, IF YOUR CHILD CANNOT SIGN DUE TO HIS/HER YOUNG AGE, PLEASE COMPLETE THE FOLLOWING STATEMENT:

Waiver of Assent

The assent of ______________________________ (**first name** of child/minor) was waived because of age.

____

Signature of Parent or Legally Authorized Representative

Date: ____________________

7.4 Appendix D:

The self-administered questionnaire on demographics, SES, language use and language skill.

Questionnaire on Demographic Information, Socioeconomic Status and Language Background

The information you are going to give in this questionnaire is going to be strictly used for the purposes of the present στθδυ. All information will be kept strictly confidential and only the researcher and her two supervisors will have access to it.

<u>A. Demographic information</u>

- FIRST & LAST NAME: ....

  ....
- Age: ....
- Gender (please circle): male female
- Nationality (please circle):

Albanian Greek Other (please specify) ....

<u>B. Socioeconomic status</u>

1. What is the level of your formal education (please circle):

a) I did not finish primary school.

b) I graduated from primary school.

c) I graduated from intermediate school (between primary & high school).

d) I graduated from high school.

e) I graduated from a technical college ("TEI" in Greek).

f) I graduated from a school of higher education (private or public university).

(please turn page)

2. Are you currently employed (please circle)? YES NO

3. If yes, what exactly is your occupation?

....

....

4. What is your exact post in this job (please circle all that apply)?

a) employer (I occupy personnel)

b) I run my own business

c) higher executive or managerial personnel, in the public or private sector

d) employee

e) skilled (e.g. worker, salesperson etc.)

f) unskilled (e.g. worker, salesperson etc.)

(please turn page)

C. Language background and language history

1. In which country were you born?

Albania ☐ Greece ☐ Other ☐ (please specify) ______________

2. In which country have you spent most of your life?

Albania ☐ Greece ☐ Other ☐ (please specify) _____________

3. For how many years have you been living in Greece? _____________ years

4. In the years you have been living in Greece, have you travelled to another country/ies? YES NO

5. If yes, in which country/ies have you travelled to and for how long did you stay there?

a) ………………..country, for …………………months

b) ………………..country, for …………………months

c) ………………..country, for …………………months

d) ………………..country, for …………………months

6. What is your native language? …………………………….

7. Do you speak any language other than your native one? YES NO

8.If yes, what is/are that/those language/es?

a)..

b)..

c)...

d)...

(please turn page)

9. On a scale 1 to 5, please state how often you use this/these language/es (apart from your native language):

Rarely 1 2 3 4 5 Very often

Language a) 1 2 3 4 5

Language b) 1 2 3 4 5

Language c) 1 2 3 4 5

Language d) 1 2 3 4 5

10. On a scale 1 to 5, please rate how well you speak, read, understand and write in this/these language/ges (apart from your native language):

Not well at all 1 2 3 4 5 Very well

Language	**Speak**	**Read**	**Understand**	**Write**
1.				
2.				
3.				
4.				

(please turn page)

11. For the language/es you speak, <u>other than your native language</u>, please state with whom you use it/them and approximately for how many hours per day:

	Language	**Hours per day**
With my mother		
With my father		
with my siblings		
With my children		
With other relatives		
With my roommate/s		
With my partner		
With friends		
With colleagues		

12. For the language/es you speak, <u>other than your native language</u>, please state how old were you when you started learning them and whether you learned them by formal lessons (e.g. at school, by private language lessons), or by informal learning (e.g. at home, at work, from friends) or both:

Language	**Age of learning**	**Formal lessons (yes/ no)**	**Duration of formal lessons (in years)**	**Informal learning (yes/ no)**	**Duration of informal learning (in years)**

1.					
2.					
3.					
4.					

(please turn page)

13. If you have any other remarks about your language history that you think may be important for your ability to use this/these language/es, please feel free to write them here:..

..

..

..

..

..

..

…………………………………………………………………………………….

End of questionnaire.

Thank you for your participation.

7.5 Appendix E:

The parental questionnaire on demographics, SES, language use and language skill of the participating child.

Questionnaire on Demographic Information, Socioeconomic Status and Language Background

The information you are going to give in this questionnaire is going to be strictly used for the purposes of the present research. All information will be kept strictly confidential and only the researcher and her two supervisors will have access to it.

- FIRST & LAST NAME: ....

  ....

- relation to the child who is going to participate in the study: (please circle)

  PARENT GUARDIAN

Section 1: To be completed by the parent/ guardian of the child who is going to participate in the study.

A. Demographic information of the child who is going to participate in the study:

Date of birth: ....

Grade in primary school he/she is attending right now: ....

Gender (please circle): boy girl

Nationality (please circle):

Albanian Greek both Greek & Albanian other (please specify)....................

Language the child speaks (please circle):

Albanian Greek both Greek & Albanian other (please specify)....................

B.1 Socioeconomic status (of the mother of the child who is going to participate in the study)

1. What is your formal education (please circle):

a) I did not finish primary school.

b) I graduated from primary school.

c) I graduated from intermediate school (between primary & high school).

d) I graduated from high school.

e) I graduated from a technical college.

f) I graduated from a school of higher education (private or public university).

2. Are you currently employed (please circle)? YES NO

3. If yes, what exactly is your occupation?

....

....

4. What is your exact post in this job (please circle all that apply)?

a) employer (I occupy personnel)

b) I run my own business

c) higher executive or managerial personnel, in the public or private sector

d) employee

e) skilled (e.g. worker, salesperson etc.)

f) unskilled (e.g. worker, salesperson etc.)

(please turn page)

B.2 Socioeconomic status (of the father of the child who is going to participate in the study)

1. What is your formal education (please circle):

a) I did not finish primary school.

b) I graduated from primary school.

c) I graduated from intermediate school (between primary & high school).

d) I graduated from high school.

e) I graduated from a technical college.

f) I graduated from a school of higher education (private or public university).

2. Are you currently employed (please circle)? YES NO

3. If yes, what exactly is your occupation?

....

....

4. What is your exact post in this job (please circle all that apply)?

a) employer (I occupy personnel)

b) I run my own business

c) higher executive or managerial personnel, in the public or private sector

d) employee

e) skilled (e.g. worker, salesperson etc.)

f) unskilled (e.g. worker, salesperson etc.)

(please turn page)

C. Language background and language history of the child who is going to participate in the study.

1. In which country was the child born?

Albania ☐ Greece ☐ Other ☐ (please specify) ______________

2. In which country has the child spent most of his/her life?

Albania ☐ Greece ☐ Other ☐ (please specify) ______________

3. For how many years has the child leaved in Greece? _____________ years

4. For the time that the child has been living in Greece, has he/she travelled to another country/tries? YES NO

5. If yes, in which country/ies has he/she travelled and for how long has he/she stayed there?

a) ………………..country, for …………………months

b) ………………..country, for …………………months

c) ………………..country, for …………………months

d) ………………..country, for …………………months

6. Does the child do any extracurricular activity related to language (e.g. private language school/ private language lessons at home/ other kind of language-related activity)? YES NO

(please turn page)

7. If yes which are those activities, for how many hours per week and for what language? (please complete the table appropriately)

activity	**hours per week**	**in what language**
1.		
2.		
3.		
4.		

End of Section 1.

The next Section (Section 2) is to be completed by the child who is going to participate in the study, with the aid of the parent/s.

(please turn page)

Section 2: To be completed by the child who is going to participate in the study, with the aid of the parent/ guardian.

1. **Do you use any language other than Greek at your house?** YES NO
2. **If yes, what is that language?** ....
3. **If yes, how often do you use that language at your house?** (please tick the appropriate box)

Always ☐ Most of the time ☐ Not much ☐ Rarely ☐

4. **If you use a language other than Greek, how well do you:**

- Speak in that language?

Very well ☐ Well ☐ Not well ☐ Not at all ☐

- Read in that language?

Very well ☐ Well ☐ Not well ☐ Not at all ☐

- Understand that language?

Very well ☐ Well ☐ Not well ☐ Not at all ☐

- Write in that language?

Very well ☐ Well ☐ Not well ☐ Not at all ☐

(please go on to the next page)

5. Before you started going to school, you spoke:

Albanian ☐ Greek ☐ Other (please specify) ☐ ______________

6. Are you being taught a language at school <u>other</u> than Greek? YES NO

7. If yes, what is that language? ....

8. For how long have you been taught that language at school?

Less than a year ☐ More than 1 year ☐ More than 3 years ☐

9. How well do you:

- <u>Speak Greek?</u>

  Very well ☐ Well ☐ Not well ☐ Not at all ☐

- <u>Read in Greek?</u>

  Very well ☐ Well ☐ Not well ☐ Not at all ☐

- <u>Understand Greek?</u>

  Very well ☐ Well ☐ Not well ☐ Not at all ☐

- <u>Write in Greek?</u>

  Very well ☐ Well ☐ Not well ☐ Not at all ☐

(please go on to the next page)

10. What language do you use with your parents? ....

11. What language do you use with your siblings (if you have any)?........................

12. What language do you use with your friends? ....

13. What language do you use with your relatives (e.g. grandmother, grandfather, aunt/s, uncle/s, cousin/s)? ....

14. What language do you use with your classmates and teachers? ....

End of questionnaire. Thank you for your participation.

(Please return the questionnaire to the teacher of the child.)

7.6 Appendix F:

Description of (a) scoring of SES items and (b) differences between language groups in the constructs measured by the Questionnaire in Demographics & Language Background Questionnaire for Experient 1 with Adults.

The SES level of a respondent (2 to 7= low SES coded as 1, 8 to12= middle SES coded as 2, ≤13= high SES coded as 3) was determined by his/her total score on 1 item on educational level and 3 items on occupational status. Questions on language background were also included, as well as on international travel history, age of arrival in the country, spoken languages, age of exposure to the nonnative language(s), context and frequency of spoken languages and level of formal education in either language. Moreover, perceived language proficiency was assessed by 4 questions on reading, writing, comprehending and pronouncing abilities in both languages, because language proficiency may differ for these different language skills, thus all these modalities should be tested (for a review see Mindt et al., 2008).

Table 6.6.1. Detailed description of scoring of items on SES.

Education Level		Occupational Status	
Item	**Points**	**Item**	**Points**
Item I: years of education	From 0 points= did not finish elementary school, to 5 points=higher education graduate	Item I: employed or unemployed	0 points= unemployed, 1 point= employed
		Item II: open-ended on occupation type	1 point= farmer/ blue-collar worker 2 points= white collar worker/ professional or tradesman

	Item III: position in occupation	1 point= worker, 1 point= unskilled, 2 points= skilled, 3 points= business owner, 4 points= business owner with staff in his/her lease, 5 points= executive member of public or private sector

Table 6.6.2. Description of participants' proficiency level in a second language.

	Comprehend	Speak	Read	Write
	M (SD)	M (SD)	M (SD)	M (SD)
monolinguals	0 (0)	0 (0)	0 (0)	0 (0)
bilinguals	5 (0)	5 (0)	4 (2)	3 (2)
mixed	3 (0)	3 (2)	3 (2)	3 (2)

Note: Language Skill scores: from 0(not at all) to 5(very well).

Table 6.6.3. SES level, frequency of L2 Use and Skill in an L2 of the participants.

	SES			Language Use	Language Skill
	M (SD)	Minimum score	Maximum score	M (SD)	M (SD)
Bilinguals	6.41 (1.82)	3	11	4.91 (0.25)	4.03 (0.82)
Monolinguals	5.9 (1.71)	3	10	0.25 (0.15)	0.2 (0.19)
Mixed	7.89 (2.31)	5	11	0.58 (0.55)	2.65 (1.58)

SES cutoff scores: 2 to 7= low SES, 8 to12= middle SES, ≤13= high SES
Language Skill scores: from 0 (not at all) to 5(very well).
Language Use scores: from 0 (no L2 use) to 5(very often use L2).

Table 6.6.4. Means (in years) of age of exposure in L2, formal and informal lessons in L2 of bilinguals.

Age of exposure in L2	Formal lessons in L2 (in years)	Informal lessons in L2 (in years)
M (SD)	M (SD)	M (SD)
14 (10)	4 (5)	18 (10)

7.7 Appendix G:

Description of (a) scoring of SES items in Demographics & Language Background Questionnaire and (b) differences between language groups in the constructs measured by the Questionnaire, for Experiment 1 with Children.

Table 6.7.1. Detailed description of scoring of items on SES.

SES section	Item	Scoring (in points)
Educational level	Item I: years of education	From 0 points= did not finish elementary school, to 5 points=higher education graduate
Occupational status	Item I: employed or unemployed	0 points= unemployed, 1 point= employed
	Item II: open-ended on occupation type	1 point= farmer/ blue-collar worker 2 points= white collar worker/ professional or tradesman
	Item III: position in occupation	1 point= worker, 1 point= unskilled, 2 points= skilled, 3 points= business owner, 4 points= business owner with staff in his/her lease, 5 points= executive member of public or private sector

Differences between Language groups in SES level, Language Use & Language Skill

Some monolinguals attended tutorials on a language other than Greek (L2) after school, hence their scores on some L2 variables. None of the parents of the monolingual children reported speaking a language other than Greek at home and all parents were of Greek nationality.

The mean of the variables reflecting skill in L2 (i.e. how well one comprehends, speaks, reads and writes in L2) was taken as an index of the Language Skill. As shown by a series of independent t-tests between monolingual and bilingual children, using the Bonferroni correction for multiple comparisons, in all the variables describing their Language background, bilinguals were significantly more skilled, more experienced, were exposed in an L2 in a much earlier age and used L2 much more often than their monolingual peers. In fact, the bilingual children of this experiment scored almost perfectly on all the variables reflecting skill in an L2. Additionally, our monolingual children were never exposed to an L2 in their living environment (i.e. never received informal lessons in an L2), in clear contrast to the bilinguals. These confirm the Language state, either monolingual or bilingual, of the participants (see Table 6.7.2).

Table 6.7.2. Means and (Standard Deviations) for the variables constituting the Language background of monolinguals (n=24) and bilinguals (n=26) in Experiment 2, and related *t*-values.

	Monolinguals M (SD)	**Bilinguals M (SD)**	***t*-values**
Comprehend L2	0.70 (0.88)	4 (0.00)	19.268*
Speak L2	0.61 (0.78)	4 (0.00)	22.123*
Read L2	0.52 (0.67)	3.73 (0.53)	18.720*
Write L2	0.43 (0.51)	3.58 (0.64)	18.814*
L2 skill	0.57 (0.69)	3.83 (0.24)	22.670*
L2 frequency of use	0.43 (0.51)	3.54 (0.51)	21.357*
Age of exposure in L2	7.75 (0.59)	0.65 (1.60)	13.584*
formal lessons in L2	1.21 (1.52)	3.5 (1.33)	5.485*
Informal lessons in L2	0.00 (0.00)	8.67 (1.53)	25.933*

** sig. at the 0.005 level (Bonferroni correction for multiple comparisons)*
Comprehend, Speak, Read, Write L2: from 0 (no L2 knowledge) to 4 (very well). L2 Skill= sum of Comprehend, Speak, Read, Write L2 /4.
Language Use scores: from 0 (never use L2) to 4 (very often use L2). Formal and Informal lessons in L2 in years.

7.8 Appendix H:

Description of differences between language groups in the constructs measured by the Questionnaire, for Experiment 2 with Children.

Six monolingual children had just started attending tutorials on a language other than Greek after school, hence their scores on some L2 variables. None of the parents of the monolingual children reported speaking a language other than Greek at home and all parents were of Greek nationality. The language groups were compared in these variables. Due to the highly unequal sample sizes for this comparison (i.e. monolinguals = 6, bilinguals = 28), the non-parametric Mann-Whitney U Test was used. Bilingual children differed widely in their skill in a second language, age of exposure to an L2 and all the other L2 characteristics from the monolinguals, $p < .00001$.

Table 6.8.1 Means and (Standard Deviations) for the variables constituting the Language background of monolinguals (n=6) and bilinguals (n=28) in Experiment 2.

	Monolinguals M (SD)	**Bilinguals M (SD)**
Comprehend L2*	0.22 (0.49)	3.86 (0.36)
Speak L2*	0.19 (0.4)	3.79 (0.42)
Read L2*	0.22 (0.49)	3.39 (0.83)
Write L2*	0.19 (0.4)	3.39 (0.83)
L2 skill*	0.20 (0.44)	3.61 (0.53)
L2 frequency of use*	0.19 (0.4)	2.50 (0.51)
Age of exposure in L2*	6.33 (0.82)	0.46 (1.04)
formal lessons in L2*	1.11 (0.25)	2.75 (0.44)
Informal lessons in L2*	0.00 (0.00)	6.18 (1.16)

** sig. at the 0.005 level (Bonferroni correction for multiple comparisons)*
Comprehend, Speak, Read, Write L2: from 0 (no L2 knowledge) to 4 (very well). L2 Skill= sum of Comprehend, Speak, Read, Write L2 /4.
Language Use scores: from 0 (never use L2) to 4 (very often use L2).
Formal and Informal lessons in L2 in years.

7.9 Appendix I:

Description of scoring of SES items in Demographics & Language Background Questionnaire for Experiment 4 with Older Adults.

The SES section of the questionnaire comprised items on participants' education level as well as the type and position of their occupation before retirement. Similar to previous studies assessing the SES of Greek participants according to their educational level (e.g. Benetou et al., 2000) or Type of Occupation (e.g. Natsiopoulou & Melissa-Halikiopoulou, 2009), the total score of each participant in one item on educational level and 2 items on occupational nature were taken as an index of his/her SES level (see Table 6.9.1).

Table 6.9.1. Detailed description of scoring of items on SES.

Education Level		Occupational Status	
Item	**Points**	**Item**	**Points**
Item I: years of education	From 0 points= did not finish elementary school, to 5 points=higher education graduate	Item II: open-ended on occupation type	1 point= farmer/ blue-collar worker 2 points= white collar worker/ professional or tradesman
		Item III: position in occupation	1 point= worker, 1 point= unskilled, 2 points= skilled, 3 points= business owner, 4 points= business owner with staff in his/her lease, 5 points= executive member of public or private sector

Questions about the participant's gender, age and nationality were also included. Finally, in the Language Background section of the self-report measure, questions included international travel history, age of arrival in the country, spoken languages, age of exposure to the nonnative language(s), context and frequency of spoken languages and level of formal education in L2. Additionally, perceived language skill was assessed by 4 questions on reading, writing, comprehending and pronouncing abilities in both languages (for a review see Mindt et al., 2008).