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The moderating effect of bilingualism on lifespan cognitive development.

Abstract

A growing amount of studies have explored the possible effects of bilingual experience on cognitive processes such executive functions; the early positive findings were followed by recent studies that have failed to replicate the so-called bilingual advantage. So far, evidence remains scarce with regard to developmental cognitive trajectories through the lifespan, as a function of bilingual experience. In the present work, we analyse a relatively large (N = 326) and comprehensive set of data from Albanian-Greek bilingual and Greek monolingual children (N = 119) and adults (N = 207), who were matched on SES level, intelligence and gender. Participants were assessed with the ANT and the Simon task. Results suggest that bilingual experience moderates age-related changes in monitoring in childhood, with overall RTs negatively related to age in both language groups, yet this relationship is weaker among bilingual children. Similar findings were also observed among adults, with age and monitoring correlated among monolinguals, but not in the bilinguals. Finally, only the monolingual participants showed a significant correlation between age and resistance to interference capacity (Simon effect). In conclusion, bilingualism seems to exert a differential influence on the relationship between age, attentional monitoring and resistance to interference capacity depending on the developmental phase studied and the measures obtained.

The moderating effect of bilingualism on lifespan cognitive development

There is no arguing to the importance of bilingualism (or multilingualism) in our current global society. The ever augmenting trend of cultural openness, globalization, as well as migration has led to a stunning number of people effectively using at least one language other than their mother tongue on a daily basis. For instance, among the 54% of Europeans that reported being able to hold a conversation in a second language, 24% reported using their second language every day or almost every day, whereas there were participants that reported using a third (8%) or even a fourth language (6%) equally frequently (European Commission, 2012, pp. 12, 41). Moreover, 21.6% of Americans age five and older reported speaking a language other than English at home in 2016 (New American Community Survey Statistics for States and Local Areas, 2017). Therefore, exploring the advantages and disadvantages associated with second language learning has become the focus of psychological research and policy making in the last decades. While most people would agree that there are obvious socio-economic advantages associated with speaking more than one language (i.e. cultural agility, linguistic diversity, enhanced communication and enriched professional and educational opportunities), the idea that bilingualism may as well lead to cognitive benefits does not seem to hold up to research scrutiny (see Adesope, Lavin, Thompson, & Ungerleider, 2010; Hilchey & Klein, 2011; Lehtonen, Soveri, Laine, Järvenpää, de Bruin, & Antfolk, 2018; Paap, Johnson, & Sawi, 2015; von Bastian, Souza, & Gade, 2016).

The *bilingual cognitive advantage* hypothesis has initially been supported by studies that found bilingual participants to outperform monolinguals in non-linguistic tasks that tap on *executive functions* (*EFs;* e.g., Bialystok, Craik, Klein, & Viswanathan, 2004), and specifically, on inhibitory control (Costa, Hernández, & Sebastián-Gallés, 2008; Bialystok, & DePape, 2009; Bialystok, et al., 2004; Zied et al., 2004), mental set shifting or cognitive switching (Prior & Gollan, 2011; Prior & MacWhinney 2010; Soveri, Rodriguez-Fornells, & Laine, 2011), and working memory (Bialystok, Craik, & Luk, 2008), as well as more general cognitive processes, such as monitoring and cognitive flexibility (Kemp, 2007; Morales, Gómez-Ariza, & Bajo, 2013; Morales, Yudes, Gómez-Ariza, & Bajo, 2015). It has been also supported that bilingualism buffers relevant cognitive decline with increasing age in adulthood (Bialystok, Martin, & Viswanathan, 2005), and even delays the onset of dementia by an average of 4.5 years, by increasing the *cognitive reserve* of older adults (Alladi et al., 2013). And this effect appears to be independent of factors that can influence cognitive development and performance, such as education, occupation and migrant status.

The main explanation proposed to account for observed beneficial effects relies on the assumption that everyday control of two languages constitutes a type of cognitive training for bilinguals, exerting positive influences on cognitive processes other than language (see discussion in Bialystok, 2017). Specifically, the role of inhibitory control (related to a bilingual inhibitory control[1] “advantage”, Hilchey & Klein, 2011) is considered important in resisting cross-linguistic interference, given that both languages are simultaneously activated in the bilingual mind, even when one of them is currently being used (Blumenfeld, & Marian, 2007; Colomé, 2001; Costa & Caramazza, 1999; Costa, Miozzo, & Caramazza, 1999; Dewaele, 2001; Green, 1998; van Heuven, Schriefers, Dijkstra & Hagoort, 2008; Martin, Dering, Thomas, & Thierry, 2009; Thierry

[1] However, also see Costa, Miozzo, and Caramazza (1999) for a language selection model that does not involve inhibition of the competing language.

and Wu, 2007). Other authors (Bialystok, 2017), also support that early bilingual experiences lead to enhanced executive attention, which would not necessary involve inhibition. Several authors have also referred to a *general monitoring system* (Hilchey & Klein, 2011; Costa et al., 2009; Lehtonen et al., 2018) to explain findings of faster overall RTs in bilinguals, relative to monolinguals, in interference tasks (see Botvinick, Braver, Barch, Carter, & Cohen, 2001). That is, bilinguals need to monitor the linguistic context in order to select the appropriate language for communication, and this would give them an advantage in cognitively demanding tasks (Costa et al., 2009).

From these theoretical perspectives, the amount of bilingual experience should relate to the benefit associated. Particularly, based on the inhibitory control approach, the greater the use and experience with the languages, the more automatic the lexical activation in each, and the greater the cross-linguistic interference. Thus, as children get older and with accumulated experience, any positive effect of bilingualism should gain in magnitude. Some studies seem to support the influence of long-term experience and practice with two languages on cognitive performance (Kapa & Colombo, 2013; Summers, Bohman, Gillam, Peña, & Bedore, 2010; Carlson & Meltzoff, 2008; Luk, De Sa, & Bialystok, 2011). In these studies though, the amount experience (years of being a bilingual) is usually confounded with the age at which participants are exposed to L2. Disentangling such effects, however, is important, since different EF components appear to follow differential developmental trajectories. Specifically, inhibition develops rapidly, with marked conceptual gains during the preschool years (Demetriou et al., 2017); though, refinements are still observed in middle childhood and even later, being particularly evident in demanding conditions (see reviews in Best & Miller, 2010 and

Best, Miller, & Jones, 2009). Furthermore, there are studies reporting better cognitive control even in infants exposed to two languages (Kovàcs & Mehler, 2009), and young preschoolers (e.g, Poulin-Dubois, Blaye, Coutya, & Bialystok, 2011; Carlson & Meltzoff, 2008). Other factors than language practice may have contributed to such beneficial effects; with consistency of young children's exposure to the languages, due to greater home confinement, being a potential candidate. Early childhood is also considered to be the most neurologically plastic developmental period, thus allowing for even greater relevant environmental modulation (see Demetriou et al., 2017). Finally, there is evidence to suggest greater benefits in younger children. For example, Hansen, Macizo, Duñabeitia, Saldaña, Carreiras, Fuentes, and Bajo (2016) observed a bilingual advantage in working memory updating and proactive control in the younger but not in the older children's groups. Researchers hypothesised that younger children may actually be faced with greater attentional control demands due to greater cross-linguistic interference from the better developed language.

Despite a number of positive findings being reported, the number of studies that fail to replicate the suggested bilingual advantage in different populations is augmenting. Morton and Happer (2007) were amongst the first to question the so-called *bilingual cognitive advantage.* More recent studies have failed to show differences between bilingual and monolingual children in inhibitory control measures (Anton et al., 2014; Duñabeitia et al., 2014; Ladas, Carroll, and Vivas, 2015). The lack of a positive effect of bilingualism on EFs has also been replicated in a large-scale study with 1,740 children, 9 to 10 years old, who spoke a second language, and a subgroup of 606 bilingual children who used frequently both languages (Dick et al., 2019). Null findings have also been reported in recent studies with young adults (Paap & Greenberg, 2013; Vivas, Ladas, Salvari, & Chrysochoou, 2017) or older adults (Antón, Fernández-García, Carreiras, & Duñabeitia, 2016; Kousaie & Phillips, 2012; Clare et al., 2014). In a similar line, the bilingual advantage was not replicated in one of the few life-span studies conducted so far (Gathercole et al., 2014), assessing Welsh-English bilinguals (650 participants–children to older adults) on a card sorting, the *Simon,* and a metalinguistic judgment tasks.

Moreover, several recent reviews (Hilchey & Klein, 2011; Klein, 2015; Valian, 2015) have concluded that the evidence supporting a bilingual advantage in inhibitory control in children and young adults is mixed and less robust than in older adults. It should be noted though, that Lehtonen et al. (2018) did not find a significant moderating effect of age (coded as a categorical variable) on the bilingual EF advantage in a recent meta-analysis. In contrast, the bilingual advantage on overall RT has been suggested to be more robust, across all ages (Hilchey & Klein, 2011); this suggestion has also been challenged, though (see Klein, 2015; see also Donelly et al.'s, 2016 suggestion for a relevant observed effect possibly being subject to publication bias). These studies also point out to a huge diversity among the studies in how bilingualism is defined; with null results, at least in part, possibly related to noise across study comparisons. That is why exploring within sample variation, with the present study focusing on bilingual experiences and age-related cognitive performance, has an added value.

Surprisingly, although age is one of the key variables discussed in relation to any potential positive effect of bilingualism on cognitive development and performance, there are only a couple of studies looking at the bilingual cognitive advantage across the life span from childhood to the older age (Bialystok and colleagues, 2005; Gathercole et al., 2014). Given its implications for policy making in education and healthy aging, understanding the impact of bilingualism on cognition across the life span is of crucial importance. There is also a need for studies that provide detailed descriptions of the characteristics of bilinguals who are recruited from different, under-examined populations, given the heterogeneous and diverse experience of being bilingual across the world.

The present study attempted to provide relevant insight. To our knowledge, it is the third study to investigate the bilingual advantage from a developmental perspective, employing age as a continuous variable. However, the other two studies have focused only on adults and have yielded somewhat different results. Subramaniapillai, Rajah, Pasvanis, and Titone (2018) found that bilingual experience (earlier age of acquisition and greater use of non-native language/s) buffered against age-related decline in an unspeeded measure of executive control (WCST), yet only in women. Whereas, Incera and McLenna (2018), using mouse-tracking methodology, found that bilingual experience (self-reported use of language/s) influenced the overall level of cognitive performance (Stroop task), but not the rate of cognitive decline with age. It is also noted that two other lifespan studies (Bialystok et al., 2005; Gathercole et al., 2014), as well as studies involving between-groups comparisons at different age phases (e.g., middle versus older adulthood in Bialystok et al., 2004, 2008; Lee Salvatierra & Rosselli, 2011), specified age groups by literature-based cut-off points and used ANOVAs to examine how bilingualism interacts with age in affecting cognitive performance. However, as Stuart-Hamilton (2012, p.3) pointed out for adulthood, *'It is perfectly possible to argue* *that by having a threshold age, we lose sight of the fact that age is a part of the continuum. We do not become old overnight when we reach 60'.* In line, from a statistical standpoint, dichotomizing variables that are primarily continuous can result in information loss, such as loss of variance that may be accounted by the original variable (Maxwell & Delaney, 1993), and decrease of power to detect interaction effects (Frazier, Tix, & Barron, 2004).

Moreover, these few life span studies did not match (or at least did not report relevant information) bilingual and monolingual participants on key confounds, such as SES or general intelligence (although Incera & McLennan, 2018 did control in their analyses for the effects of education and general cognitive reserve). Thus, aiming to shed further light on the interplay of bilingualism and cognitive development, we opted to view age as continuum in a study involving Greek-speaking monolingual and Albanian-Greek bilingual children and adults, matched on SES level, gender and non-verbal intelligence. Let us note that the Albanian-Greek population is not only a prevalent, but also rather homogeneous bilingual population in Greece; specifically, in terms of immigrant status, SES mostly low, as well as heritage culture (same country of origin, i.e. Albania). Socioeconomic status has been identified as an important modulator of not only the suggested bilingual cognitive advantage (see Morton & Harper, 2007; Naeem et al., 2018; see Paap et al., 2015), but cognitive development more generally (Burneo-Garcés, Cruz-Quintana, Pérez-García, Fernández-Alcántara, Fasfous, & Pérez-Marfil, 2019; Magnuson & Duncan, 2006; Mezzacappa, 2004). Thus, SES, also in relation to immigrant status as well as culture, has been regarded important to consider and carefully control for in studies exploring the cognitive correlates of bilingualism.

As part of an extended phase of data collection with the Albanian-Greek bilingual population, we analysed data from 326 participants, including data from two previous studies (110 children from Ladas et al., 2015 using the ANT, and 90 young adults from Vivas et al., 2017 using the ANT), and data from 126 new participants, including older adults, as well as a Simon task along with the ANT. Adopting a different, cross-sectional developmental approach to the analysis of the specific pool of data, we aimed at exploring possible moderating effects of bilingualism on the relationships between age and resistance to interference, alerting, orienting, and monitoring (overall RT) in childhood (early, middle childhood and preadolescence years; 5-13) and adulthood (emerging, middle and late adulthood years; 18 to 90). At the period of data collection, there was not a sufficient pool of adolescent Albanian-Greek bilinguals to draw from for the current study; following migration in the 90s, the population initially consisted mostly of adults (younger and older) and only later on, from children that were born and growing up in Greece.

To measure resistance to interference, orienting and alerting we employed the ANT, which has comparable child and adult versions, and has thus been widely used to measure the three attentional functions across the life span (Rueda, Fan, McCandliss, Halparin, Gruber, Lercari, & Posner, 2004 in children; Fan, McCandliss, Sommer, Raz, & Posner, 2002, Fan, McCandliss, Fossella, Flombaum, & Posner, 2005 in young and middle-aged adults; and Mahoney,Verghese, Goldin, Lipton, & Holtzer, 2010; Fernandez-Duque, & Black, 2006; Jennings, Dagenbach, Engle, & Funke, 2007 in older adults). A second task, the *Simon,* was used to measure resistance to interference in adults (used with older adults as well; see Van der Lubbe, & Verleger, 2002) in an attempt to discuss whether the suggested bilingual benefit is subject to the specific demands set by the paradigms employed (see Paap, Johnson, & Sawi, 2014). These tasks were chosen because they both require selection of the task-relevant response in the face of conflictive (irrelevant) automatic activation (the flanker arrow direction in the ANT and stimulus location in the Simon task). This task situation parallels the cognitive conflict that bilinguals deal with when having to select the target language in the face of co-activation of the context-irrelevant language. Although most researchers would agree that cognitive conflict tasks require some sort of selection process, there is currently a debate about the exact nature of the mechanisms underlying performance in these tasks (e.g., Paap, Anders-Jefferson, Mikulinsky, Masuda, & Mason, 2019; Rey-Mermet, Gade & Oberauer, 2018). The examination of the validity of interference tasks as inhibition measures is beyond the scope of the present study; however, in the light of the aforementioned debate, we opted at using the term *resistance to interference* to refer to goal-directed selection of the target stimulus/response when there is overlapping activation of conflictive information. Thus, a smaller interference effect would be indicative of more efficient selection of the target stimulus/response, regardless of whether goal-directed selection is achieved by inhibition of the unwanted information (e.g, Friedman & Miyake, 2004) or activation/up-regulation of the relevant information in the processing stream (e.g, Egner, & Hirsch, 2005). Importantly, the ANT and Simon tasks also provided us with useful measures of monitoring; as Lehtonen et al. (2018) suggest, global RTs in such interference tasks "*have been more commonly associated with general monitoring demands*" (p. 28).

Summing up, the present study aimed at a cross-sectional investigation of child and adult cognitive development as a function of bilingualism. We set the following questions: Does bilingualism moderate the relationship between age and cognitive performance, exerting a positive influence in child cognitive development, and limiting, on the other hand, cognitive decline with age?

Based on the existing developmental literature, we expected age to significantly correlate with capacity to resist interference; specifically, the younger the children and the older the adults, the greater in magnitude the flanker and Simon effects. Moreover, if the management of co-activation of two or more languages in the bilingual mind asserts positive influences on the development of resistance to interference processes, then we expect a significant interaction between age and bilingualism in the prediction of the conflict effect in children. That is, the relationship between age and capacity to resolve conflict will be stronger in bilingual children. Our study, also allowed us to test the hypothesis of an effect of accumulative bilingualism experience. Since, all the children that participated in the present study were exposed to L2 before the age of three, we could disentangle the effect of the length of bilingualism experience from the effect of its onset. If the length of experience plays a role, then we should find bilingualism to significantly moderate the relationship between age and cognitive performance, with the positive correlation between age and cognitive performance being stronger in bilingual children. Along the same line, if bilingual experience contributes to a cognitive reserve that can help older adults compensate for brain changes as a result of aging, then age and capacity to resolve conflict (flanker and Simon effects) should be more weakly related in bilingual adults. Additionally, if a monitoring system is positively influenced by bilingualism, then we expect a significant interaction between age and bilingualism in predicting overall RTs in children and adults, in directions that are consistent with the aforementioned conflict effect trends.

Finally, one could assume that any bilingual benefit in executive attention might potentially have a knock on effect on alerting and orienting as well; since the three attentional networks have been suggested to interact (Callejas, Lupiánez, & Tudela, 2004; Fuentes, Vivas, Langley, Chen, & Gonzalez-Salinas, 2012). Relevant evidence is inconclusive, however: two studies have reported greater alerting effects in young adult bilingual participants relative to monolinguals (Costa et al., 2008; Marzecová et al., 2013), but others have failed to replicate this effect (Anton et al., 2014; Tao, Marzecová, Taft, Asanowicz, & Wodniecka, 2011; Vivas et al., 2017 in young adults). Thus, in the present study, the interaction of bilingualism and age in predicting alerting and orienting performance was left to be explored.

Method

Participants

A total of 326 participants (119 children, aged 5 to13, and 207 adults, aged 18-90) were assessed as part of a long-term bilingual recruitment with the Albanian-Greek bilingual population in North Greece. Data from 110 children were analyzed in Ladas et al., 2015, and data from 90 young adult participants were analyzed in Vivas et al., 2017, serving, however, the exploration of different research questions, with the bilingual advantage approached from a cognitive rather than developmental perspective. Thus, in the present study we include additional data from 9 more children and 117 new young, middle and older adult participants.

Specifically, we analyse data from all 119 children, as well as from 136 adults given the ANT. We also analyse data from 122 adults given a Simon task version with two WM load conditions; the latter was not also given to children because data collection took place at different phases and was restricted by the assessment duration allowed for each particular sample. It is noted that 51 participants were shared by the ANT and the Simon samples, since they completed both tasks.

Specifically, children ($N = 119$, see characteristics in Table 1) were recruited from two public schools in the center of Thessaloniki (second largest city in Greece) and from villages near Xanthi (a small city in Northern Greece). Among them, 54 were Greek-speaking monolinguals, all born in Greece and not having lived abroad. The remaining 65 children were early bilinguals (see De Houwer, 1998), exposed to Albanian and Greek within the first three years of life. Their parents were Albanian in origin and had migrated to Greece. A self-report questionnaire was used to gain insight into participants' language background and use (Ladas et al., 2015; see also Vivas et al., 2017). The questionnaire was developed based on previous studies on bilingualism and second language learning (e.g. Brown, Brown, & Eggett, 2009; Costa et al., 2008; Portocarrero, Burrightm, & Donovick, 2007). Relevant parental reports, also confirmed by children, indicated Albanian as the "mother" tongue, spoken in the family context, and Greek as the language spoken with siblings, friends and schoolmates-peers in educational and social settings. The small but significant negative correlation ($r = -.298$, $p = .024$) found between age and language dominance -absolute language switching cost asymmetry-, suggested a tendency for more balanced bilingualism with increasing age. Bilingual children had all attended Greek kindergarten and were currently attending Greek primary school (they had not received any formal education in Albanian). Only the older children (51 out of 119) had been receiving English classes at school (as part of upper elementary grades curriculum), for one to two hours per week.

The adult participants (N = 207) were also recruited from both urban and rural areas of Northern Greece, via Albanian associations and networks, as well as from two day care centers for senior citizens in the city of Xanthi and the western suburbs of Thessaloniki. All senior participants (60+ year-olds) scored above 26 (indicating healthy cognitive status) in *The Montreal Cognitive Assessment* (Nasreddine et al., 2005). Among the 207 adult participants, 101 were bilinguals. There were two criteria for including adult participants in the bilingual group: (a) reporting competence in using both Albanian and Greek on a regular basis (see Bialystok, 2009) to satisfy daily needs at home, social and/or professional settings (Grosjean, 1982; 2008; 2010; Dopke, 1992); a relevant criterion was adopted in children's case, as noted above, and (b) reporting not only current exposure to both languages, but also being a bilingual in the two languages for several years already. Among the 101 bilinguals, only two reported less than 10 years of bilingual experience (five and seven, accordingly); the relevant group mean was 38.55 with a SD of 18.55. About half of the adult bilingual participants, 55%, were either born in Greece or had immigrated to Greece during childhood or adolescence (L2 age of acquisition – AoA: 0-3 years for 10%, 4-12 years for 39%, and 13-17 years old for 6%). The remaining participants had migrated to Greece and had acquired Greek (L2) at 18 or later; this later group of participants consisted mostly of middle and older age adults

($Mean_{age}$ = 55.76, *SD* = 13.59), who have lived in Greece for an average of 19.28 years (*SD* = 5.07).Thus, the group of adult bilinguals, unlike the children's group, was heterogeneous in terms of bilingualism profile and consisted of simultaneous, early sequential, as well as late bilinguals. This was also supported by the lack of a significant correlation between age and the language dominance (absolute switching cost asymmetry; $r = .007$, $p = .459$).

Finally, the adult monolingual group (N = 106; age *M* = 39.51, *S*D = 19.92), consisted of Greek-speaking adults, all born in Greece, and not having used a second language on a daily/regular basis in the past. Among them, 88 reported not having learned a foreign language, whereas the remaining participants reported minimum relevant exposure in the past (mostly to English) in the context of public school classes of one - two hours per week (several participants had only completed low educational levels).

Non-verbal intelligence, vocabulary in each language spoken and SES were measured to more accurately describe the samples and confirm bilingual-monolingual group matching in the case of each data set analysed (see descriptive and information on matching in Tables 1 and 2). Specifically, participants were given the *Raven's Standard Progressive Matrices Test* (Raven, 1958), as well as the productive vocabulary subtest (requiring word definitions) of the *Wechsler* intelligence scales for children and adults (WISC and WAIS III, respectively; Wechsler, 1997; see also Koulakoglou, 1998; Ladas et al., 2015; Vivas et al., 2017). A composite SES score was calculated based on ratings provided by the adult participants and children's parents on their (a) educational level (from 0 - did not finish elementary school, to 5 – university/ higher education graduate),

(b) type of occupation (0 - unemployed, 1- blue collar, 2 - white collar), and (c) position in occupation (0 -unemployed; 1 - unskilled worker; 2 – skilled/ specialized professional; 3 - business owner; 4 - business owner with staff; 5 - executive member of the private or public sector). Socioeconomic status (level) was attributed to participants, applying specific cut-off scores on the sum of the aforementioned measures for adults and the average parental (mother-father) ratings (i.e. low SES: total score up to 7; middle status: 8 to12; high SES: 13 or greater; see SES ratings also in Ladas et al., 2015 and Vivas et al., 2017).

Measures and Procedure.

The ANT task. The adult and child ANT versions were employed, as adopted by Fan et al. (2002). Participants were told to keep their eyes on the fixation cross (+) throughout the experiment. The duration of the fixation point varied randomly across trials from 0 to 1200 ms. In each trial, a warning cue appeared for 100 ms. There were four different types of warning cues: spatial, double, no, and central. After an interval of 400ms, the target array was presented above or below fixation. The target was an arrow, pointing left or right; it was always presented centrally, alone or flanked by four identical arrows, according to the condition: flanker and target arrows pointing towards the same direction in the congruent trials, or towards opposite directions, in the incongruent trials. The ANT adult task consisted of 288 experimental trials, 96 trials for each congruency condition (Congruent, Incongruent and Neutral), and 72 trials for each cue type condition (spatial, alerting, no, and central). The ANT child consisted of 168 experimental trials, 56 trials for each congruency condition, and 42 trials for each cue condition. The following measures were provided: Overall RT (global RT measure), an *Alerting* network score (mean RT for no cue trials minus mean RT for alerting trials), an *Orienting* network score (mean RT for trials for central cue trials minus mean RT for spatial cue trials) and a *Conflict*-resistance to interference- measure (mean RT for Incongruent trials minus mean RT for congruent trials). A child version of the task (Rueda et al., 2004) with fishes instead of arrows as stimuli was employed for the children.

The Simon task. We used a Simon task version with two WM-load conditions (as adopted by Bialystok et al., 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), Laterilized-2 (an either brown or blue square appeared on the left or right of fixation) and Laterilized-4 (identical to Centre-4 condition, except that the square was presented left or right of fixation). The experiment consisted of two blocks, with 24 practice trials (presented first) and 96 experimental trials, 48 trials overall for each congruency condition (Congruent and Incongruent) and 24 trials for each combination congruency-colour. The task always began with the Centre condition, which was the easiest one so that participants got accustomed to it. Then, the Lateralized conditions followed. This order was counterbalanced between blocks. The number-of-colours condition was randomized within each block.

Each trial began with a sound (a high tone “beep”) for 300 ms, followed by two coloured circles, left and right or above and below central fixation, depending on the condition, which remained on the screen until response. After response, there was a further blank screen for 500 ms. In the 2-colours condition, participants were instructed to press the left key (A on the keyboard) when they saw a blue square and the right key

(L on the keyboard) when they saw a brown square. The instructions for the 4-colours condition were presented as four separate rules, so as to maximize WM load: 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. The following measures were derived: Overall RT (Global RT measure), and Simon interference effects (mean RT for incompatible trials minus mean RT for compatible trials) in the 2-colour condition, and Simon interference effect in the 4-colour condition.

Language switching task. A modification of the language-switching task developed by Meuter and Allport (1999) was employed to obtain an objective measure of how balanced bilingual participants were (see also Verhoef et al., 2009; Yeung, & Monsell, 2003). Specifically, we calculated from the task, the absolute switching cost asymmetry (SCA). That is we subtracted the cost of switching from L1 to L2 from the cost of switching from L2 to L1. In the task, a yellow digit from 1 to 9 was presented in the forefront of the Greek or the Albanian flag. Participants were required to read aloud each digit presented in the language primed by the flag (Ladas et al (2015); Vivas et al., 2017). The task consisted of two blocks of 475 trials each; 70% of the trials were non-switching trials, and 30% were switching trials.

The study was approved by the Ethics Committee of the University of Sheffield. Informed consent was obtained. Each participant was tested individually, in a quiet room. The administration of the demographics and language background questionnaires was followed by the intelligence and vocabulary tests. Participants then completed the computerized tasks -ANT for children and adults, and Simon for adults. Measures were administered in counterbalanced order. Testing lasted approximately 90 minutes for the monolingual and 105 minutes for the bilingual participants.

Results

Participants' median response time for correct trials was obtained for each measure. We excluded participants from the analysis if their overall accuracy was below 70%. According to this criterion, 2 children participants were eliminated from the original sample recruited. The overall accuracy for the participants included in the analyses was 95% for the Simon task, 97% for the child ANT and 98% for the adult ANT.

In the sections that follow, we first report the results of correlation analyses exploring the relationships between age and the cognitive measures obtained for children and adults per task data set and irrespectively of language group. If significant correlations were observed between age and cognitive measures (reported in Table 3), separate moderated regression analyses were then run to examine the possible moderating role of bilingualism in each observed relationship. The moderated regression analysis steps, stable in all analyses run, are described in the first relevant section, regarding children's data (see Field, 2013; Frazier et al., 2004). Relevant coefficients are presented for each step and model in Tables 4, 5, and 6 regarding each data set. It is noted that the assumptions for moderated regression analyses were examined and found satisfactory (Field, 2013; Frazier et al., 2004; Wilcox, 2017). Moreover, moderation analyses were conducted with bootstrapping procedures to increase confidence in the derived results (see Field, 2013). These procedures were used to calculate main and interaction effects (on 1000 bootstrap samples), along with their significance levels and a 95% confidence interval.

In the cases that significant additional variance was explained by the Age X Bilingualism cross-product in the second step of a given moderated regression analysis (see coefficients in Tables 4, 5, 6). Each significant moderating effect was further explored, describing the relationship between age and each cognitive measure within each language group; we also visualized the effect, via graphical presentation of the simple regression slopes for each moderator group (bilinguals and monolinguals) (see Figures 1-3). It is finally noted that in the cases that a moderating effect was observed for the ANT conflict or the Simon effects, we explored whether the pattern observed could be influenced by age-related changes in speed of processing; this was achieved via the conduction of stepwise regression analyses, with age and the baseline (ANT/ Simon Neutral) condition RTs entered as predictors and the given effect (ANT conflict/Simon), as the outcome measure.

Children

Pearson's correlation analysis was firstly conducted to explore the relationships between the age and the cognitive measures obtained for children (interference effects, alerting and orienting scores, and overall RT; see correlations for each sample in Table 3).

-Insert Table 3 about here-

In order to examine the potential moderating effects of bilingualism on the significant relationships observed between age and the overall RT measure, the conflict and orienting effects, we proceeded with relevant moderated regression analyses. Each moderated regression analysis was conducted in two steps (see Table 4): the predictors were entered firstly (i.e. the age values, standardized within the children's sample, and the dummy coded bilingualism variable, with bilinguals coded as 1 and monolinguals as 0), followed by the computed Bilingualism X Age interaction term, added in the second step. Specifically, the predictors' cross product explained an additional 2% of the variance in children's overall RT, over and above the 32% explained by the first order effects of bilingualism and age. In other words, bilingualism moderated the relationship between age and overall RT. In further exploring the significant interaction, we report the correlation coefficients for age and overall RT per language group and regress the overall RT onto age per language group (see simple regression slopes per language group, in *Figure 1*). The significant moderation actually indicates smaller age-related changes in global RT in the bilingual group ($r = -.454$, $p < .001$) as compared to the monolingual children ($r = -.664$, $p < .001$; $z = 1.641$, $p = .005$).

In contrast, the results of independent moderated regression analyses showed that bilingualism did not moderate the relationship between age and neither the conflict and orienting effects (the predictors' cross-product failed to significantly increase the amount of variance explained by the regression model in the second step of the analyses, see Table 4).

-Insert Table 4 and Figure 1about here-

Adults

ANT task. We carried moderated regression analyses, employing the exact same procedure described above, in order to examine the potential moderating effects of bilingualism on the observed significant relationships (see Table 3) between adults' age (standardized within the relevant sample; N = 136) and overall RT, the alerting and orienting effects. Specifically, in the moderated analysis run with overall RT, the cross-product of the predictors (bilingualism and age) explained an additional 3% of the variance in the outcome variable, over and above the 46% explained by the first order effects of bilingualism and age. In other words, bilingualism moderated the relationship between age and overall RT (see also Figure 2 for regression effects per language group). The significant moderation actually indicates a weaker positive correlation between age and the overall RT measure of ANT for the bilingual ($r = .449$, $p < .001$) as compared to the monolingual adults ($r = .836$, p < .001; $z = 1.641$, $p < .0001$).

In the moderated regression analysis run for the alerting measure, the first model (including age and bilingualism as predictors) failed to reach significance [F (2,133) = 2.71, $p = .070$]; we therefore did not proceed with the examination of a moderating effect. Finally, in the regression analysis run for the orienting scores (see Table 5), the cross product of the predictors (Age X Bilingualism) failed to significantly increase the amount of variance explained by the regression model, thus, not indicating significant moderation.

-Insert Table 5 and Figure 2 about here-

Simon Task. In order to examine the potential moderating effects of bilingualism on the significant relationships observed (see Table 3) between adults' age (N = 122) and the overall RT, as well as Simon low–load condition effect with RTs, we proceeded with relevant moderated regression analyses. Specifically, in the analysis run for the overall RT Simon measure (see Table 6), the cross product of the predictors (age and bilingualism) failed to significantly increase the amount of variance explained by the regression model, thus not indicating a significant moderating effect of bilingualism. On the other hand, the Bilingualism X Age interaction term explained an additional 6% of the variance in analysis run for the Simon effect at the low WM load condition, over and above the 7% explained in the first model. In other words, bilingualism moderated the specific relationship (see also Figure 3 for regression effects per language group). Specifically, the correlation between age and the Simon effect at the low WM load condition was significant and positive for the monolingual adults ($r = .441$, $p < .001$), though not also for the bilingual participants ($r = -.020$, $p = .880$; $z = 2.657$, $p = .004$).

Baseline RTs as a predictor of resistance to interference. In order to explore whether the developmental pattern observed in the case of the conflict effect (ANT) in children and the Simon-2 effect in adults, could be influenced by age-related changes in speed of processing, we conducted stepwise regression analyses, with age and the baseline (ANT/ Simon Neutral RTs) condition entered as predictors in each case. In the analysis run for children's conflict effect, only one model was extracted, with age ($b = -.25$, $p = .007$) explaining 6% of variance in the outcome variable. That is, baseline RTs was not a significant predictor of the conflict effect in the ANT-child ($b = .108$, $p = .335$).

Similarly, we conducted stepwise regression analyses, with age and baseline condition (Simon-2 neutral) entered as predictors and the Simon-2 effect as the outcome measure. One model was extracted with age (b = .24, p = .007) explaining 5.9% of variance in Simon-2 effect in adults. Therefore, neither the interference effect in the Simon task was influenced by adults' baseline RTs (b = - . 174, p = .121).

Discussion

We followed an alternative approach to study the effects of bilingualism on cognitive performance; a current debate in the literature, with recent findings questioning the robustness of the initially suggested positive effects (e.g. Dick et al., 2019). We aimed at testing whether learning and using a second language daily in life has a positive impact on cognitive performance in both childhood and adulthood, by strengthening age – cognitive performance correlations in children, yet weakening them in adults. Specifically, we conducted moderated regression analyses with age entered as a continuous predictor and bilingualism as a potential binary moderator; this allowed us to explore significant moderating effects, based on the contribution of the variables' cross-product (interaction) to the prediction of variance in resistance to interference, alerting, orienting, and monitoring (overall RTs). The analyses were run on large samples of bilingual and monolingual children (aged 5 to 13) and adults (aged 18 to 90), matched on potential confounding factors (SES level, general intelligence, and gender). Bootstrapping procedures were employed to further increase confidence in the derived results (see Field, 2013; Frazier et al., 2004).

Resistance to interference and monitoring

We found the patterns expected for children based on the literature. That is, the older the children, the more effective the resistance to interference (smaller interference effects) and conflict monitoring (faster global RTs). This finding is in agreement with cross-sectional (Rueda et al., 2004; Pozuelos, Paz-Alonso, Castillo, Fuentes, & Rueda, 2014) and longitudinal studies (Suades-Gonzales et al., 2017). Further, the pattern observed for the resistance to interference measure was not influenced by possible age-related changes in speed of processing (baseline condition RTs).

The results for adults were also aligned to those described in the literature. That is, the older the participants the less effective the resistance to interference (Mahoney et al., 2010; Van der Lubbe, & Verleger, 2002); although only in the low WM load (2-colour) condition of the Simon task. Also in adults' case, this pattern was not influenced by possible changes in speed of processing (baseline condition RTs) with increasing age. In addition, the older the participants the less effective their monitoring capacity (greater overall RTs). This relationship is consistent with Salthouse's hypothesis of a general slowdown in speed of processing with greater age (Salthouse, 1985, 1994).

The present finding of a task-specific relationship between age and resistance to interference fits well with previous evidence showing that age effects on conflict resolution are more likely to be observed with the Simon, than with flanker tasks. Specifically, de Bruin and Della Sala (2017) and Wild-Wall et al. (2008) have proposed that older adults may have better attentional focus to the target and/or slower perceptual processing of peripheral flankers; this might lead to less interference and hence, to a lack of age-related effects on resistance to interference with the specific task. Similarly, the relationship between age and monitoring was task-specific, evident in the case of the ANT task only. As suggested by Costa et al. (2008), the latter may be a more suitable task to measure monitoring, since it is less "contaminated" by other cognitive processes, such as working memory in the case of the Simon task. Moreover, in the Simon task version used in the present study, neutral trials were presented in separate blocks, thus, possibly imposing fewer demands on monitoring. Furthermore, the relation between age and the Simon effect was also condition specific (evident in the 2-colour condition only). Research has also shown that age-related influences on stimulus-response incompatibility effects may be condition-specific (Proctor, Vu & Pick, 2005). Due to a high WM load and a greater number of S-R alternatives (Proctor, Vu & Pick, 2005) in the 4-color condition, the activation of the response code might have been delayed, thus, leading to less conflict, since the automatic activation of the location would have decayed by then (Hommel, 1994).

The analyses in children did not show a significant moderating effect of bilingualism in the age - resistance to interference relationship. This finding also agrees with the limited in number studies that have directly discussed bilingualism by age interactions regarding EF development (e.g. Bialystok, 1999), or run analyses between language groups in difference ages (e.g. Gathercole et al., 2014). On the other hand, in line with the hypothesis that bilingualism enhances cognitive reserve (Bialystok, Craik, & Freedman, 2007; Guzmán-Vélez & Tranel, 2015) we found bilingualism to interact with adults' age in predicting variance in resistance to interference. Specifically, only the adult monolingual participants, but not the bilinguals, showed a significant relationship between age and resistance to interference capacity (see Figure 3). The evidence regarding a protective effect of bilingualism on cognitive decline with age is mixed; while some studies have reported this effect in adults without a diagnosis of dementia (e.g. Subramaniapillai et al., 2018), others have failed to replicate such findings (e.g. Incera & McLennan, 2018). One key factor, determining the observation of the benefit, may be migrant status; Chertkow, Whitehead, Phillips, Wolfson, Atherton, and Bergman (2010), for instance, reported a stronger protective effect of bilingualism for the onset of memory problems and the diagnosis of dementia in their immigrant subgroup. Our sample of adult bilingual also consisted of immigrants from Albania; however, unlike in Chertkow et al.'s study, they were matched with the monolingual sample on key confound factors. As Chertkow and colleagues pointed out, the life experiences of the immigrants may, however, differ from non-immigrant populations in unexpected ways. In our case, the bilingual adult population migrated from Albania, a country that emerged from the communist regime in the 90s, back then considered one of the poorest countries in Europe (World Bank Report). We could only speculate on effects of population characteristic in the present study. Future research may further look into socio-cultural determinants (e.g., normative roles) of cognitive functioning, also when exploring the potential protective effects of bilingualism on cognitive decline with age.

Bilingualism also significantly moderated the relationship between age and monitoring (overall RTs) in both children and adults. Interestingly, contrary to the hypothesis that bilingualism exerts a positive influence on monitoring capacity development (Hilchey & Klein, 2011), age was positively but more weakly related with monitoring in our bilingual children (see Figure 1). Whereas in adults, consistent with the hypothesis of a positive (protective) effect of bilingualism, increasing age was related with worse monitoring (slower overall RTs), yet to a lesser extent in the bilingual group (see Figure 2).

The finding of a weaker relationship between age and monitoring capacity in bilingual children does not fit either with the accumulative bilingual experience hypothesis, which would predict a stronger positive correlation in bilinguals. Yet, findings are consistent with recent evidence also reporting better performance of monolingual over bilingual children in overall RTs (see Gathercole et al., 2014; Morton & Harper, 2007; see also Paap et al., 2014 for monolingual adults outperforming bilinguals). Such findings are usually left unexplained; however, one may assume that they may reflect effects of other variables, often not feasible to control for or measure (Valian, 2014). In our study as well, for instance, bilingual children sample consisted of second generation immigrants, subjected to different socio cultural influences as compared to Greek-speaking monolinguals. We should note however, that, as with the adult sample, bilingual and monolingual children were matched on SES and general intelligence. With regard to parental SES, however, recent studies suggest that it is language development that mediates its effects on executive functions development (see Noble, Norman & Farah, 2005). Future studies, preferably longitudinal, could shed further light on the interplay of language and cognitive development, as a function of bilingual experience, as well as SES, in the sensitive early and middle childhood years.

Overall, our findings suggest that the influence that bilingualism exerts on the relationship between age and either resistance to interference capacity and monitoring (overall RTs) might be subject to the developmental phase studied. Actually, most studies so far, discussing cognitive correlates of bilingualism in between-subject comparisons, have focused on specific developmental phases, strictly matching participants on age. In a recent review of such studies, Valian (2014) concluded that although evidence on a bilingual advantage in executive functioning is overall mixed, more consistent and robust benefits have been reported for older adults. In contrast, studies with relatively large samples of children tend to report insignificant effects (Dick et al., 2019; Duñabeita et al., 2014; Gathercole et al., 2014). This conclusion is in agreement with our findings. As suggested (Valian, 2015), bilingualism effects may interact or be obscured by other challenging activities that are typical for both bilinguals and monolinguals at earlier developmental phases (e.g., exercise), relative to older adulthood; these activities can induce brain plasticity, thus, also exerting effects on executive functioning.

Furthermore, the different patterns observed in children and adult samples in our study may be related, at least in part, to bilinguals' "profiles". In contrast to the more homogeneous group of children (all early and balanced bilinguals), adult bilinguals had a greater within-group variance in L2 AoA. Costa and Santesteban (2014) argued that early bilinguals, who are highly proficient in both languages (versus L2 learners), might use qualitatively different mechanisms to manage both languages; specifically, they may not use reactive inhibition as a way of selecting the target lexicon. Also, it has been proposed that bilinguals who are less balanced - like our adult bilinguals -, may be faced with greater attentional control demands due to greater cross-linguistic interference from the language better developed (Hanse et al., 2016; Toa et al., 2011). In our study, however, the magnitude of the Simon effect did not significantly correlate with variability in bilingual experience, as reflected in a language dominance measure -absolute language switching cost asymmetry - (r = -.195, p = .150) or L2 AoA (r = .019, p = .887). In line, Paap and colleagues' (2014) did not find systematic influences of early versus late, or balanced versus dominant bilingualism, and L2 AoA on attentional control in a large sample of 384 bilinguals. Similarly, in a recent meta-analysis of studies with adults, Lehtonen and colleagues (2018) found no moderation of bilingualism effects on inhibition when AoA or L2 proficiency was taken into account.

Alternatively, it could be the case that learning a second language early in life does not have a significant or necessarily positive impact on cognitive performance (see Gathercole et al., 2014); but once the system has undergone major re-organization and development, the neural and cognitive reserve resulting from learning and frequently using a second language actually compensates for brain and cognitive changes associated to aging (see also Luk, Bialystok, Craik & Crady, 2011). Future, cross-sectional as well as longitudinal studies could explore these hypotheses; preferably, not only relying on behavioural measures, but also investigating brain network connectivity in bilinguals and monolinguals of different ages and profiles.

Alerting and orienting

Developmental studies suggest that the ability to orient to exogenous cues matures relatively early and does not change significantly during childhood (Rueda et al., 2004, Pozuelo et al., 2014; Suades-Gonzales et al., 2017). In our study, however, we did find a positive correlation between age and efficiency in orienting to peripheral cues in 5 to13 year-old children. This finding could be due to faster orienting to valid cues with increasing age. With regard to alerting, it has also been suggested that children are able to process warning cues as efficiently as adults, but some studies have reported that younger children benefit more than older ones from warning cues, since they have worse tonic alertness in the absence of a warning cue (Pozuelo et al., 2014; Rueda et al., 2004). We did not observe a significant correlation between age and alertness in the present study, however. Such differences in findings might be due to sample characteristics; our group, for example, consisted of children from very low SES backgrounds.

In line with previous evidence, our data also suggest associations between age and orienting and alerting in adulthood. Specifically, in adults, as age increased, alerting scores decreased, while orienting scores increased. To our knowledge only three studies have investigated the effect of age on alertness and orienting (using the ANT). While Mahoney et al. (2010) did not find an interaction with age and alerting scores, Fernandez-Duque et al. (2006) found greater alerting scores in the group of older adults, and Jennings et al. (2007) found reduced alerting scores in the older group after adjusting for overall speed of processing. However, Fernandez-Duque et al. had increased the warning cue duration to 500 ms in their study, a factor that might account for the differences in results. Ours findings are aligned with those of Jennings et al, in a bigger sample and with age approached as a continuous variable; the older our adult participants, the lower the capacity to exploit alerting cues.

On the other hand, the positive age – orienting correlation observed in the present study is not in line with the findings of the aforementioned studies, where orienting was not significantly affected by age. Irrespectively of methodological differences between the studies that might account for discrepancy in the findings (as also noted above), our observation of a positive correlation between capacity to orient attention and age fits well with the *compensatory hypotheses* of aging (Cabeza, Anderson, Locantore, & McIntosh, 2002; Stern et al., 2005); older adults seem to compensate for shortcomings by making better use of help - in this case the spatial cue - than younger adults.

Finally, although we did find significant correlations between age and alerting and orienting effects, none of these relationships were moderated by bilingualism. This finding is in agreement with the existing, yet limited, literature investigating alerting and orienting processes as a function of bilingualism (see null effects with children in Anton et al., 2014; and with young adults in Tao et al., 2011 and Vivas et al., 2017). Only two studies have reported a bilingual advantage, yet only in alerting. Costa et al. (2008) suggested that bilinguals may have higher alertness state to help detect and resolve more efficiently cognitive conflict. However, the conflict effect was not modulated by the presence or absence of a warning cue in their analyses, neither in Marzecová et al (2013). In addition, although Costa and colleagues did not compare the language groups within each cue condition (no-cue and double-cue), a closer look at the RT data suggests that bilinguals were faster in both conditions (no-cue: 26 ms of difference; double-cue: 36 ms difference). Thus it appears that bilingual participants did not only benefit more from the warning cue but also had better tonic alertness. Alternative, Marzecová and colleagues proposed that the benefit in alerting could be due to a more efficient domain-general executive network in bilingual participants, since research has suggested that response preparation may be controlled by this network.

Summing up, evidence on the effects of bilingualism on alerting and orienting is limited and so far, mixed. To our knowledge, the present study is the first to investigate the associations between age and the specific attentional networks in samples of bilingual and monolingual children and adults, controlling for SES and general intelligence. Our findings suggested that bilingualism does not exert a relevant moderating influence, neither in childhood, nor in adulthood.

Conclusions

The present study investigated resistance to interference, orienting and alerting, as well as monitoring (overall RTs) in relatively large and rather homogenous samples of bilingual children and adults (speaking Albanian-Greek, mostly low in SES), matched to Greek-speaking monolinguals on gender, SES, and non-verbal intelligence. While bilingualism did not exert a moderating positive effect in children, the relationships between age and either monitoring or resistance to interference capacity were weaker or even insignificant for bilingual adults. One limitation of the study was that it did not involve adolescents; as they were underrepresented in the specific population for several years, given migration of mostly Albanian adults to Greece in the early phases, and a general decrease in the Albanian-Greek population lately, due to the recent financial crisis in Greece.

Finally, even in the cases where a moderating effect was observed, the cross-product of the bilingualism and age variables predicted a modest level of variance in each cognitive outcome. Future research, preferably adopting longitudinal or sequential designs to control for cohort effects and intra-individual differences across time,could shed further light on cognitive development trajectories as a function of bilingualism.

References

Abutalebi, J., Guidi, L., Borsa, V., Canini, M., Della Rosa, P. A., Parris, B. A. & Weekes, B. S. (2015). Bilingualism provides a neural reserve for aging populations. *Neuropsychologia, 69,201-210*.

Adesope, O. O., Lavin, T., Thompson, T., &Ungerleider, C. (2010).A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research, 80*(2), 207-245.

Alladi, S., Bak, T. H., Duggirala, V., Surampudi, B., Shailaja, M., Shukla, A. K., ...&Kaul, S. (2013). Bilingualism delays age at onset of dementia, independent of education and immigration status. *Neurology, 81*(22), 1938-1944.

Antón, E., Duñabeitia, J. A., Estévez, A., Hernández, J. A., Castillo, A., Fuentes, L. J., ...&Carreiras, M. (2014). Is there a bilingual advantage in the ANT task? Evidence from children. *Frontiers in Psychology*, *5*, 398.

Antón, E., Fernández García, Y., Carreiras, M., & Duñabeitia, J.A. (2016). Does bilingualism shape inhibitory control in the elderly? *Journal of Memory & Language, 90*, 147–160.

Ardila, A., Ostrosky-Solis, F., Rosselli, M., & Gómez, C. (2000). Age-related cognitive decline during normal aging: the complex effect of education. *Archives of Clinical Neuropsychology*, *15*(6), 495-513.

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development*, *81*(6), 1641-1660.

Best, J. R., Miller, P. H., & Jones, L. L. (2009). Executive functions after age 5: Changes and correlates. *Developmental review*, *29*(3), 180-200.

Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition*, *12*(1), 3-11.

Bialystok, E. (2010). Bilingualism. *Wiley Interdisciplinary Reviews: Cognitive Science, 1,* 559-572.

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin, 143*(3), 233.

Bialystok, E., Craik, F. I., & Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia*, *45*(2), 459-464.

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*(4), 859.

Bialystok, E., Craik, F. I., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology and Aging, 19*(2), 290-303.

Bialystok, E., Craik, F. I., & Luk, G. (2012). Bilingualism: consequences for mind and brain. *Trends in Cognitive Sciences*, *16*(4), 240-250.

Bialystok, E., & DePape, A. M. (2009). Musical expertise, bilingualism, and executive functioning. *Journal of Experimental Psychology: Human Perception and Performance, 35*(2), 565.

Bialystok, E., & Martin, M. M. (2004). Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science, 7*(3), 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*(1), 103-119.

Blumenfeld, H. K., & Marian, V. (2007). Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking. *Language and Cognitive Processes*, *22*(5), 633-660.422.

Brayne, C., & Calloway, P. (1990).The association of education and socioeconomic status with the Mini Mental State Examination and the clinical diagnosis of dementia in elderly people. *Age and Ageing, 19*(2), 91-96.

Brown, N. A., Brown, 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*(3), 424-452.

Burneo-Garcés, C., Cruz-Quintana, F., Pérez-García, M., Fernández-Alcántara, M., Fasfous, A., & Pérez-Marfil, M. N. (2019). Interaction between socioeconomic status and cognitive development in children aged 7, 9, and 11 years: a cross-sectional study. *Developmental Neuropsychology*, *44*(1), 1-16.

Cabeza, R., Anderson, N. D., Locantore, J. K. & McIntosh, R. (2002). Aging gracefully: compensatory brain activity in high-performing older adults. *Neuroimage, 17*(3), 1394-1402.

Callejas, A., Lupiáñez, J., & Tudela, P. (2004). The three attentional networks: On their independence and interactions. *Brain and cognition*, *54*(3), 225-227.

Calvo, A., & Bialystok, E. (2014). Independent effects of bilingualism and socioeconomic status on language ability and executive functioning. *Cognition*, *130*(3), 278-288.

Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11*(2), 282-298.

Chertkow, H., Whitehead, V., Phillips, N., Wolfson, C., Atherton, J., & Bergman, H. (2010). Multilingualism (but not always bilingualism) delays the onset of Alzheimer disease: evidence from a bilingual community. *Alzheimer Disease & Associated Disorders*, *24*(2), 118-125.

Clare, L., Whitaker, C. J., Craik, F. I., Bialystok, E., Martyr, A., Martin-Forbes, P. A., ... & Gathercole, V. C. M. (2016). Bilingualism, executive control, and age at diagnosis among people with early-stage Alzheimer's disease in W ales. *Journal of Neuropsychology*, *10*(2), 163-185.

Colomé, À. (2001). Lexical activation in bilinguals' speech production: Language-specific or language-independent? *Journal of Memory and Language, 45*(4), 721-736.

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., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition, 106*(1), 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. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of memory and Language*, *50*(4), 491-511.

de Bruin, A., & Della Sala, S. (2017). Effects of age on inhibitory control are affected by task-specific features. *The Quarterly Journal of Experimental Psychology*, 1-40.

De Houwer, A. (2005). Early bilingual acquisition. *Handbook of bilingualism: Psycholinguistic Approaches*, 30-48.

Demetriou, A., Spanoudis, G., Kazi, S., Mouyi, A., Žebec, M. S., Kazali, E., ... & Shayer, M. (2017). Developmental differentiation and binding of mental processes with g through the life-span. *Journal of Intelligence*, *5*(2), 23.

Dewaele, J. M. (2001). Activation or inhibition? The interaction of L1, L2 and L3 on the language mode continuum. *Bilingual Education and Bilingualism,* 69-89.

Dick, A. S., Garcia, N. L., Pruden, S. M., Thompson, W. K., Hawes, S. W., Sutherland, M. T., ... & Gonzalez, R. (2019). No evidence for a bilingual executive function advantage in the ABCD study. *Nature human behaviour*, *3*(7), 692-701.

Döpke, S. (1992). *One parent one language: An interactional approach* (Vol. 3). John Benjamins Publishing.

Duñabeitia, J. A., Hernández, J. A., Antón, E., Macizo, P., Estévez, A., Fuentes, L. J., & Carreiras, M. (2014). The inhibitory advantage in bilingual children revisited. *Experimental Psychology, 61*(3), 234-251.

Egner, T., & Hirsch, J. (2005). Cognitive control mechanisms resolve conflict through cortical amplification of task-relevant information. *Nature neuroscience*, *8*(12), 1784.

Engel de Abreu, P. M., Cruz-Santos, A., Tourinho, C. J., Martin, R., & Bialystok, E. (2012). Bilingualism enriches the poor: Enhanced cognitive control in low-income minority children. *Psychological science*, *23*(11), 1364-1371.

European Commission, Directorate-General for Education and Culture, Directorate-General for Translation and Directorate-General for Interpretation, co-ordinated by Directorate-General for Communication (2012 - a survey conducted by TNS Opinion & Social at the request of the E.C.). *Europeans and their languages - Special Eurobarometer 386.* Retrieved from: http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_386_en.pdf

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., McCandliss, B. D., Fossella, J., Flombaum, J. L. & Posner, M. I. (2005). The activation of attentional networks. *Neuroimage, 26*(2), 471-479.

Fernandez-Duque, D., & Black, S. E. (2006). Attentional networks in normal aging and Alzheimer's disease. *Neuropsychology,20*(2), 132-142.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Frazier, P. A., Tix, A. P., & Barron, K. E. (2004).Testing moderator and mediator effects in counseling psychology research. *Journal of Counseling Psychology, 51*(1), 115.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: a latent-variable analysis. *Journal of experimental psychology:*

General, *133*(1), 101.

Fuentes, L. J., Vivas, A. B., Langley, L. K., Chen, Q., & González-Salinas, C. (2012). Inhibitory mechanisms in the attentional network: A multidisciplinary approach. In M. I. Posner (Ed.), *Cognitive neuroscience of attention* (pp. 76-88). New York, NY, US: Guilford Press.

García-Pentón, L., Fernández, A. P., Iturria-Medina, Y., Gillon-Dowens, M., &Carreiras, M. (2014). Anatomical connectivity changes in the bilingual brain. *Neuroimage*, *84*, 495-504.

Gathercole, V. C. M., Thomas, E. M., Kennedy, I., Prys, C., Young, N., Guasch, N. V. et al. (2014). Does language dominance affect cognitive performance in bilinguals? Life span evidence from preschoolers through older adults on card sorting, Simon, and metalinguistic tasks. *Frontiers in Psychology 5*, 11.

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

Grosjean, F. (1982). *Life with Two Languages*. Cambridge, MA: Harvard University Press.

Grosjean, F. (2008). *Studying bilinguals*. Oxford: Oxford University Press.

Grosjean, F. (2010). *Bilingual: Life and Reality.* Cambridge, Mass: Harvard University Press.

Guzmán-Vélez, E., & Tranel, D. (2015). Does bilingualism contribute to cognitive reserve? Cognitive and neural perspectives. *Neuropsychology*, *29*(1), 139.

Hansen, L. B., Macizo, P., Duñabeitia, J. A., Saldana, D., Carreiras, M., Fuentes, L. J., & Bajo, M. T. (2016). Emergent bilingualism and working memory development in school aged children. *Language Learning*, *66*(S2), 51-75.

Hilchey, M. D., & Klein, R. M. (2011). Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes. *Psychonomic Bulletin & Review,18*(4), 625-658.

Hommel, B. (1994). Spontaneous decay of response-code activation. *Psychological research*, *56*(4), 261-268.

Incera, S., & McLennan, C. T. (2018). Bilingualism and age are continuous variables that influence executive function. *Aging, Neuropsychology, and Cognition*, *25*(3), 443-463.

Jennings, J. M., Dagenbach, D., Engle, C. M., & Funke, L. J. (2007). Age-related changes and the attention network task: An examination of alerting, orienting, and executive function. *Aging, Neuropsychology, and Cognition, 14*(4), 353-369.

Kapa, L. L., & Colombo, J. (2013). Attentional control in early and later bilingual children. *Cognitive development*, *28*(3), 233-246.

Kemp, C. (2007). Strategic processing in grammar learning: Do multilinguals use more strategies? *International Journal of Bilingualism, 4,* 241–261.

Klein, R. M. (2015). Is there a benefit of bilingualism for executive functioning?. *Bilingualism: Language and Cognition*, *18*(1), 29-31.

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

Kousaie, S., & Philips, N. A. (2012). Ageing and bilingualism: absence of a "bilingual advantage" in stroop interference in a nonimmigrant sample. *Quarterly Journal of Experimental Psychology (Hove), 65*(2), 356-359.

Kousaie, S., Sheppard, C., Lemieux, M., Monetta, L., & Taler, V. (2014).Executive function and bilingualism in young and older adults. *Frontiers in Behavioral Neuroscience, 8*: 250.

Kovács, Á. M., & Mehler, J. (2009). Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Sciences*, *106*(16), 6556-6560.

Kroll, J. F., & Bialystok, E. (2013). Understanding the consequences of bilingualism for language processing and cognition. *Journal of Cognitive Psychology*, *25*(5), 497-514.

Ladas, A. I., Carroll, D. J., & Vivas, A. B. (2015). Attentional Processes in Low Socioeconomic Status Bilingual Children: Are They Modulated by the Amount of Bilingual Experience? *Child Development, 86*(2), 557-578.

Lee Salvatierra, J., & Rosselli, M. (2011). The effect of bilingualism and age on inhibitory control. *International Journal of Bilingualism*, *15*(1), 26-37.

Lehtonen, M., Soveri, A., Laine, A., Järvenpää, J., de Bruin, A., & Antfolk, J. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. *Psychological Bulletin*, *144*(4), 394.

Luk, G., Bialystok, E., Craik, F. I., & Grady, C. L. (2011). Lifelong bilingualism maintains white matter integrity in older adults. *Journal of Neuroscience, 31*(46), 16808-16813.

Luk, G., De Sa, E. R. I. C., & Bialystok, E. (2011). Is there a relation between onset age of bilingualism and enhancement of cognitive control?. *Bilingualism: Language and cognition*, *14*(4), 588-595.

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*(4), 365-399.

Mahoney, J. R., Verghese, J., Goldin, Y., Lipton, R., & Holtzer, R. (2010).Alerting, orienting, and executive attention in older adults. *Journal of the International Neuropsychological Society, 16*(05), 877-889.

Martin, C. D., Dering, B., Thomas, E. M., & Thierry, G. (2009). Brain potentials reveal semantic priming in both the 'active' and the 'non-attended' language of early bilinguals. *NeuroImage, 47*(1), 326-333.

Marzecová, A., Asanowicz, D., Kriva, L. U., & Wodniecka, Z. (2013).The effects of bilingualism on efficiency and lateralization of attentional networks. *Bilingualism: Language and Cognition*, *16*(3), 608-623.

Maxwell, S. E., & Delaney, H. D. (1993). Bivariate median splits and spurious statistical significance. *Psychological Bulletin*, *113*(1), 181.

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.

Morales, J., Gómez-Ariza, C., & Bajo, M. (2013). Dual mechanisms of cognitive control in bilinguals and monolinguals. *Journal of Cognitive Psychology, 25*, 531–546.

Morales, J., Yudes, C., Gómez-Ariza, C. J., & Bajo, M. T. (2015). Bilingualism modulates dual mechanisms of cognitive control: Evidence from ERPs. *Neuropsychologia, 66*, 157-169.

Morton, J. B., & Harper, S. N. (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10*(6), 719-726.

Naeem, K., Filippi, R., Periche-Tomas, E., Papageorgiou, A., & Bright, P. (2018). The importance of socioeconomic status as a modulator of the bilingual advantage in cognitive ability. *Frontiers in psychology*, *9*, 1818.

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.

Nair, V. K., Biedermann, B., & Nickels, L. (2017). Effect of socio-economic status on cognitive control in non-literate bilingual speakers. *Bilingualism: Language and Cognition*, *20*(5), 999-1009.

New American Community Survey Statistics for States and Local Areas (2017). Retrieved from https://www.census.gov/newsroom/press-releases/2017/acs-single-year.html?CID=CBSM+ACS16

Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science, 8*(1), 74-87.

Paap, K. R., Anders-Jefferson, R., Mikulinsky, R., Masuda, S., & Mason, L. (2019). On the encapsulation of bilingual language control. *Journal of Memory and Language*, *105*, 76-92.

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*(2), 232-258.

Paap, K. R., Johnson, H. A., & Sawi, O. (2014). Are bilingual advantages dependent upon specific tasks or specific bilingual experiences? *Journal of Cognitive Psychology, 26*(6), 615-639.

Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances. *Cortex, 69,* 265-278.

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.

Pozuelos, J. P., Paz-Alonso, P. M., Castillo, A., Fuentes, L. J., & Rueda, M. R. (2014). Development of attention networks and their interactions in childhood. *Developmental Psychology, 50*(10), 2405.

Poulin-Dubois, D., Blaye, A., Coutya, J., & Bialystok, E. (2011).The effects of bilingualism on toddlers' executive functioning. *Journal of Experimental Child Psychology, 108*(3), 567-579.

Prior A. & Gollan, T. H. (2011).Good language-switchers are good task-switchers: Evidence from Spanish-English and Mandarin-English bilinguals. *Journal of International Neuropsychological Society, 17,* 682–691.

Prior, A., & MacWhinney, B. (2010).A bilingual advantage in task switching. *Bilingualism: Language and Cognition, 13*(02), 253-262.

Proctor, R. W., Vu, K. P. L., & Pick, D. F. (2005). Aging and response selection in spatial choice tasks. *Human factors*, *47*(2), 250-270.

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

Rey-Mermet, A., Gade, M., & Oberauer, K. (2018). Should we stop thinking about inhibition? Searching for individual and age differences in inhibition ability. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*(4), 501.

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., &Posner, M. I. (2004). *Development of attentional networks in childhood. Neuropsychologia, 42*(8), 1029-1040.

Salthouse, T. A. (1985). *Speed of behavior and its implications for cognition.* In: Birren, J. E., Schaie, K. W. (Eds.), Handbook of the Psychology of Aging. Van Nostrand Reinhold, New York, pp. 400-426.

Salthouse, T. A. (1994). The nature of the influence of speed on adult age differences in cognition. *Developmental Psychology, 30,* 240-259.

Soveri, A., Rodriguez-Fornells, A. & Laine, M. (2011). Is there a relationship between language switching and executive functions in bilingualism? Introducing a within group analysis approach. *Frontiers in Psychology 2,* 183.

Stern Y, Habeck C, Moeller J, Scarmeas N, Anderson KE, Hilton HJ, et al. (2005). Brain networks associated with cognitive reserve in healthy young and old adults. *Cerebral Cortex, 15*, 394–402.

Stuart-Hamilton, I. (2012). *The psychology of ageing: An introduction*. Jessica Kingsley Publishers.

Suades-González, E., Forns, J., García-Esteban, R., López-Vicente, M., Esnaola, M., Álvarez-Pedrerol, M., ...& Sunyer, J. (2017). A Longitudinal Study on Attention Development in Primary School Children with and without Teacher-Reported Symptoms of ADHD. *Frontiers in Psychology, 28*(2):181.

Subramaniapillais, S., Rajah, M., Pasvanis, S., & Titone, D. (2018). Bilingual experience and executive control over the adult lifespan: The role of biological sex. *Bilingualism: Language and Cognition,* 1-19.

Summers, C., Bohman, T. M., Gillam, R. B., Peña, E. D., & Bedore, L. M. (2010). Bilingual performance on nonword repetition in Spanish and English. *International Journal of Language & Communication Disorders*, *45*(4), 480-493.

Tao, L., Marzecová, A., Taft, M., Asanowicz, D., & Wodniecka, Z. (2011). The efficiency of attentional networks in early and late bilinguals: the role of age of acquisition. *Frontiers in Psychology*, *2*, 123.

Thierry, G., & Wu, Y. J. (2007). Brain potentials reveal unconscious translation during foreign-language comprehension. *Proceedings of the National Academy of Sciences, 104*(30), 12530-12535.

Tran, C. D., Arredondo, M. M., & Yoshida, H. (2015). Differential effects of bilingualism and culture on early attention: a longitudinal study in the US, Argentina, and Vietnam. *Frontiers in Psychology*, *6*, 795.

Valian, V. (2015). Bilingualism and cognition. Bilingualism: Language and Cognition, doi:10.1017/ S1366728914000522.

Van der Lubbe, R. H., & Verleger, R. (2002). *Aging and the Simon task. Psychophysiology, 39*(01), 100-110.

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

Verhoef, K., Roelofs, A., & Chwilla, D. J. (2009). Role of inhibition in language switching: Evidence from event-related brain potentials in overt picture naming. *Cognition*, *110*(1), 84-99.

Vivas, A. B., Ladas, A. I., Salvari, V., & Chrysochoou, E. (2017). Revisiting the bilingual advantage in attention in low SES Greek-Albanians: does the level of bilingual experience matter? *Language, Cognition and Neuroscience*, 1-14.

von Bastian, C. C., Souza, A. S., & Gade, M. (2016). No evidence for bilingual cognitive advantages: A test of four hypotheses. *Journal of Experimental Psychology: General, 145*(2), 246.

Wen, W., Zhu, W., He, Y., Kochan, N. A., Reppermund, S., Slavin, M. J., ... & Sachdev, P. (2011). Discrete neuroanatomical networks are associated with specific cognitive abilities in old age. *Journal of Neuroscience, 31*(4), 1204-1212.

Wechsler, D. (1997). WAIS-III administration and scoring manual. San Antonio, TX: The Psychological Corporation.

Wilcox, R. (2017). *Modern statistics for the social and behavioral sciences: A practical introduction*. Chapman and Hall/CRC.

Wild-Wall, N., Falkenstein, M., & Hohnsbein, J. (2008). Flanker interference in young and older participants as reflected in event-related potentials. *Brain Research*, *1211*, 72-84.

World Bank report, retrieved from http://documents.worldbank.org/curated/en/602151467991993190/pdf/98254-CAS-P147570-PUBLIC-Box393168B.pdf in June 27, 2019

Yang, S., Yang, H., & Lust, B. (2011). Early childhood bilingualism leads to advances in executive attention: Dissociating culture and language. *Bilingualism: Language and Cognition*, *14*(3), 412-422.

Yeung, N., & Monsell, S. (2003). Switching between tasks of unequal familiarity: The role of stimulus-attribute and response-set selection. Journal of Experimental Psychology: Human perception and performance, 29(2), 455.

Zied, K. M., Phillipe, A., Karine, P., Valerie, H. T., Ghislaine, A., & Arnaud, R. (2004). Bilingualism and adult differences in inhibitory mechanisms: Evidence from a bilingual Stroop task. *Brain and Cognition*, *54*(3), 254-256.

Table 1. Children's demographics and language background.

	Monolinguals (N = 54)		Bilinguals (N = 65)		*t*	*p*
	M (SD)	*Range*	*M (SD)*	*Range*		
Age (years)	7.75 (1.89)	5-11	7.92 (1.67)	6-13	.865	.389
Raven's CPM	23.83 (7.03)	10-36	22.88 (6.56)	4-35	.535	.594
G-WISC Voc[1]	17.87 (9.48)	5-46	16.94 (7.65)	6-39	.593	.445
A-WISC Voc[2]			16.85 (6.97)	4-38		
L2 onset[3]			.44 (.98)	0-3		
SES Level [4]	100% (low)		94% (low) - 6% (middle)		χ^2= 3.705	.091

[1]*G-WISC Voc.* = raw scores on the Greek version of the WISC Vocabulary subscale, max. 60
[2]*A-WISC Voc.* = raw scores on the Albanian version of the WISC Vocabulary subscale, max. 60
[3]L2 onset = the mean age (in years) at which participants were exposed to Greek
[4]SES = *1to 7= low, 8 to12= middle, ≥13= high SES*

Table 2. Adult's demographics and language background per task.

	Monolinguals		Bilinguals			
	M (SD)	*Range*	*M (SD)*	*Range*	*t*	*p*
ANT	N=66		N=70			
Age (years)	43.29 (20.20)	18-90	37.74 (17.66)	18-83	1.695	.92
Raven's CPM	41.13 (10.82)	20-58	39.98 (12.51)	15-57	.571	.569
G-WAIS Voc[1]	43.23 (12.21)	12-60	37.26 (13.84)	11-58	2.672	.008
A-WAIS Voc[2]	-		27.70 (15.09)			
L2 onset[3]	-		19.95 (17.65)			
Years – Bilingual[4]			17.78 (4.24)			
SES Level [5]	89% (low) - 11% (middle)		89% (low) - 11% (middle)		χ^2= .023	.878
Simon Task	N=60		N=62			
Age (years)	45.90 (22.58)	18-90	43.66 (20.49)	18-83	.574	.567
Raven's CPM	40.47 (11.56)	20-60	38.18 (12.07)	15-56	1.070	.287
G-WAIS Voc[1]	43.22 (12.74)	12-60	35.45 (13.19)	10-58	3.306	.001
A-WAIS Voc[2]	-		33.56 (13.87)			
L2 onset[3]	-		24.48 (19.10)			
Years – Bilingual[4]			19.17 (4.14)			
SES Level [5]	95% (low) - 5% (middle)		98% (low) - 2% (middle)		χ^2= 1.103	.294

[1]*G-WAIS Voc*. = raw scores on the Greek version of the WAIS Vocabulary subscale, max. 66.
[2]*A-WAIS Voc*. = raw scores on the Albanian version of the WAIS Vocabulary subscale, max. 66.
[3]L2 onset = the mean age (in years) at which participants were exposed to Greek
[4]Years –Bilingual = years of being an active bilingual
[5]SES = *1to 7= low, 8 to12= middle, ≥13= high SES*

Table 3. Correlations between age and the cognitive variables in each study

ANT	Overall RT	Conflict effect	Alerting effect	Orienting effect
Children				
Age	-.568**	-.246**	.080	.228*
Mean (SD)	726 (132)	81.82 (54.31)	71.87 (68.25)	29.97 (42.33)
Adults				
Age	.673**	-.047	-.184*	.285**
Mean (SD)	620 (123)	108.24 (56.93)	27.31 (36.65)	39.56 (39.01)

Simon task	Overall RT	Simon effect - Low WM load	Simon effect - High WM load
Adults			
Age	.639**	.244**	.023
Mean (SD)	560 (132)	48.56 (44.19)	30.36 (76.47)

Note: $^*p \leq .05$, $^{**}p \leq .01$

Table 4. Examination (employing bootstrapping) of the moderating effects of bilingualism on the relationships between children's age and overall RT, as well as conflict and orienting effects in the ANT.

Step and variables	*B*	*SE B*	*95% CI*	*β*	ΔR^2
Overall RT - ANT					
1 Age	- 75.76	10.10	-95.75, -56.53	-.57***	
Bilingualism	11.91	20.04	-31.83, 53.44	.05	.32***
$F(2,116) = 27.82$, $p < .001$					
2 Age	- 95.77	14.77	-126.76, -66.58	-.72***	
Bilingualism	12.04	19.94	-31.52, 53.22	.05	
Age × Bilingualism	41.20	19.26	1.78, 79.73	.22*	.02*
$F(3,115) = 20.47$, $p < .001$					
Conflict Resolution – ANT					
1 Age	-13.48	4.00	-20.91, -6.71	-.25***	
Bilingualism	5.03	9.78	-13.37, 23.22	.05	.06*
$F(2,116) = 3.87$, $p = .024$					
2 Age	-15.49	5.40	-26.88, -5.98	-.29**	
Bilingualism	5.04	9.75	-13.55, 23.25	.05	
Age × Bilingualism	4.13	8.07	-12.18, 19.66	.05	.00
$F(3,115) = 2.62$, $p = .054$					
Orienting – ANT					
1 Age	9.12	4.00	1.64, 17.76	.22*	
Bilingualism	21.09	7.30	6.41, 35.74	.25**	.11***
F(2,116) = 7.44, $p = .001$					
2 Age	11.37	3.30	5.57, 18.44	.27***	
Bilingualism	21.08	7.30	6.17, 35.45	.25**	
Age × Bilingualism	- 4.64	8.49	-21.17, 14.32	-.08	.00
$F(3,115) = 5.07$, $p = .002$					

Note: $^{*}p \leq .05$, $^{**}p \leq .01$, $^{***}p \leq .001$

Table 5. Examination (employing bootstrapping) of the moderating effects of bilingualism on the relationship between adults' age and the overall RT and orienting measures provided by the ANT

Step and variables	*B*	*SE B*	*95% CI*	*β*	ΔR^2
Overall RT – ANT					
1 Age	83.29	9.91	63.07, 101.03	.68***	
Bilingualism	9.89	16.47	-21.84, 40.34	.04	.46***
$F(2,133) = 55.46$, $p < .001$					
2 Age	102.54	8.05	86.38, 117.42	.84***	
Bilingualism	8.58	16.17	-22.40, 40.06	.04	
Age × Bilingualism	- 46.24	20.78	-82.59, -5.75	-.24*	.03**
$F(3,132) = 42.03$, $p < .001$					
Orienting – ANT					
1 Age	11.46	4.08	3.62, 19.61	.29**	
Bilingualism	4.47	6.62	-8.47, 16.87	.06	.09**
$F(2,133) = 6.15$, $p = .003$					
2 Age	11.44	4.84	2.38, 21.19	.29*	
Bilingualism	4.47	6.79	-8.97, 17.03	.06	
Age × Bilingualism	.03	8.74	-16.39, 17.03	.00	.00
$F(3,132) = 4.07$, $p = .008$					

Note: $^{*}p \leq .05$. $^{**}p \leq .01$, $^{***}p \leq .001$

*Table 6.*Examination (employing bootstrapping) of the moderating effects of bilingualism on the relationships between adults' age and overall RT, as well as the Simon effect at the low-WM load condition

Step and variables	*B*	*SE B*	*95% CI*	*β*	*ΔR*^{2}
Overall RT – Simon					
1 Age	84.66	10.87	62.49, 107.77	.64***	
Bilingualism	.25	19.21	-40.65, 35.47	.00	.41***
$F(2,119) = 41.05, p < .001$					
2 Age	94.17	10.87	75.57, 111.90	.71***	
Bilingualism	.18	19.21	-39.31, 35.48	.00	
Age × Bilingualism	- 20.69	10.87	-63.61, 29.65	-.11	.00
$F(3,118) = 27.82, p < .001$					
Simon - Low WM load					
1 Age	10.56	4.04	2.49, 18.54	.24*	
Bilingualism	-8.06	8.00	-23.51, 6.77	-.09	.07*
$F(2,119) = 4.32, p = .015$					
2 Age	20.24	5.22	9.98, 30.23	.46***	
Bilingualism	-8.13	7.70	-22.95, 6.36	-.09	
Age X Bilingualism	-21.06	8.13	-36.58, -4.57	-.32*	.06**
$F(3,118) = 5.57, p = .001$					

Note: *$p \leq .05$. **$p \leq .01$, ***$p \leq .001$

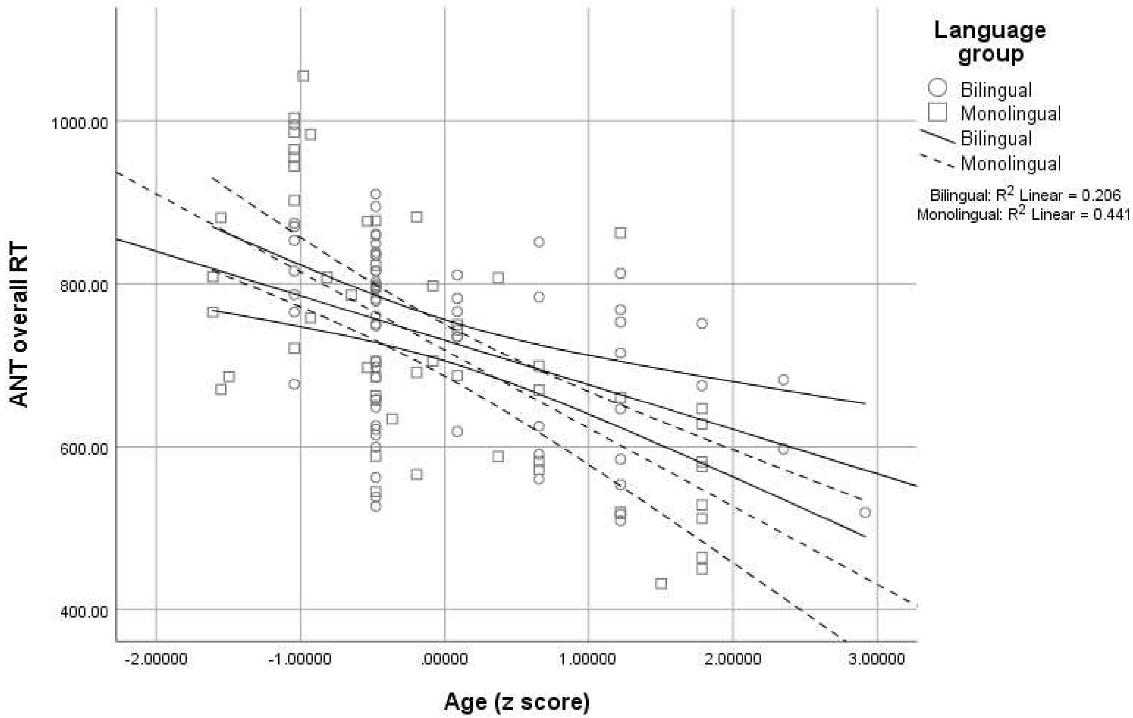

Figure 1. Interaction between bilingualism and age in predicting ANT overall RT in children

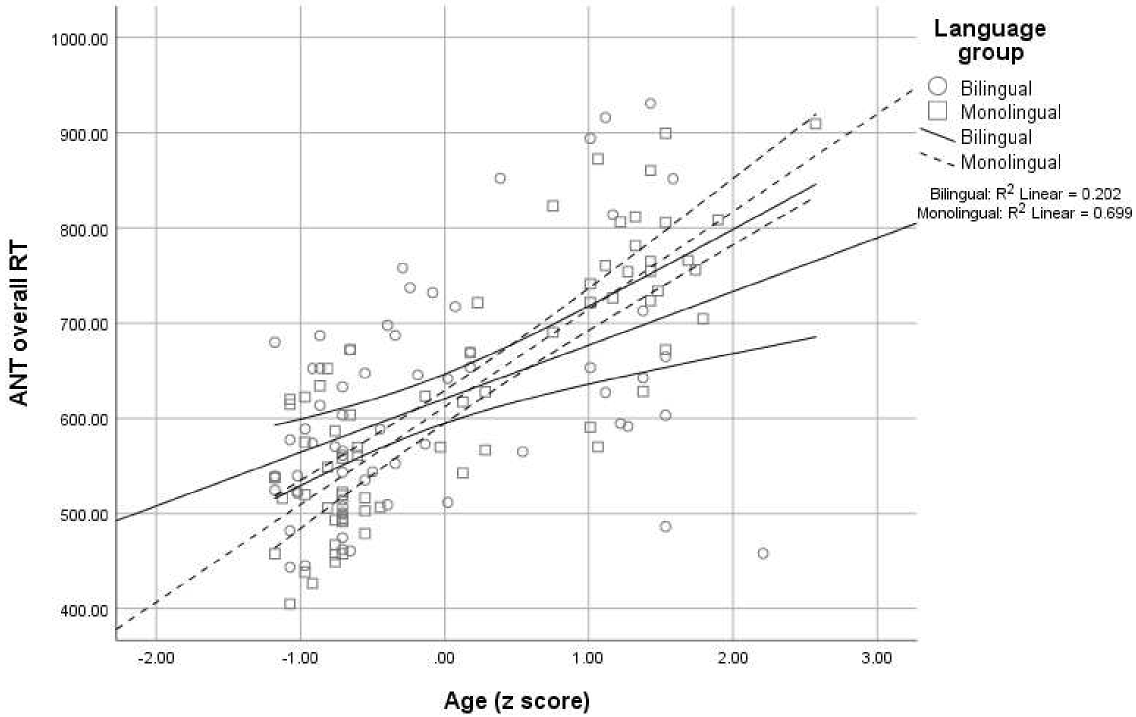

Figure 2. Interaction between bilingualism and age in predicting ANT overall RT in adults

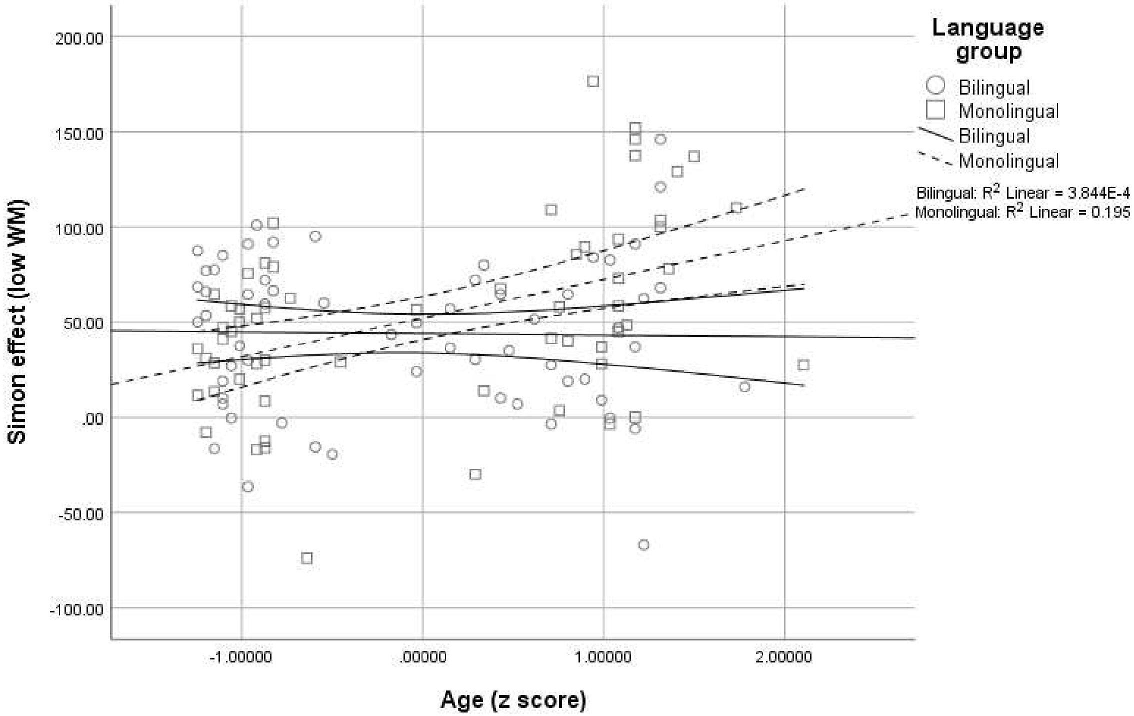

Figure 3.Interaction between bilingualism and age in predicting the Simon effect at the low WM load condition in adults.