Article



# Study of Attentional Networks of Alert, Orientation and Executive Control in Bilingual and Monolingual Primary School Children: The Role of Socioeconomic Status

Francesca Federico * , Michela Mellone , Ferida Volpi , Margherita Orsolini

Posted Date: 18 May 2023

doi: 10.20944/preprints202305.1319.v1

Keywords: attention development; socioeconomic status; bilingualism; cognitive development

*Article*

# Study of Attentional Networks of Alert, Orientation and Executive Control in Bilingual and Monolingual Primary School Children: The Role of Socioeconomic Status

**Francesca Federico *, Michela Mellone, Ferida Volpi and Margherita Orsolini**

Department of Developmental and Social Psychology, Sapienza University of Rome

* Correspondence: francesca.federico@uniroma1.it

**Abstract:** For decades, researchers have suggested the existence of a bilingual cognitive advantage, especially in tasks involving executive functions such as inhibition, shifting, and updating.Recently an increasing number of studies have questioned whether or not bilingualism results in a change in executive functions based on conflicted data reported in the literature.This study compared the performance of third-, fourth-, and fifth-grade bilingual and monolingual children on attentional and cognitive tasks. The participants were 61 monolingual and 74 bilingual children (M:114,6 months; S.D.: 8,48 months). Participants were tested on two versions of the attention task (ANT), with and without social stimuli, and in some tests investigating working memory and receptive vocabulary tests. Additionally, we examined the sociocultural status and the reasoning abilities of the participants' families. The results show how bilingualism and the sociocultural index affect attentional networks when the task uses social stimuli or has no social value. When the task implies non-social stimuli, only the sociocultural index shows a difference between groups in the executive conflict network. Examining the relationships between the different variables that we considered, it is possible to note a positive relationship between the sociocultural index and executive control with social stimuli and a negative relationship between the alert network with non-social stimuli, both already documented in the literature (Schibli et al.., 2017). Interestingly, neither the sociocultural index nor the social attentional networks correlate with working memory functioning. Therefore, even if more investigations are required, the differences in social contexts mainly affect attentional functions.

**Keywords:** attention development; socioeconomic status; bilingualism; cognitive development

## 1. Introduction

Lately, the interest in executive functions is growing as the literature supports more and more, through the results of many studies, that these abilities predict school success and, more generally, success in life (Barkley & Fischer, 2011; Stern et al., 2017; Tamm et al., 2021). Attention control is an executive functioning skill critical for operating efficiently in daily life, and gaps in these core processes have severe consequences from childhood to adulthood. It has been proven by some longitudinal studies that ADHD is related to long-term impairments in EFs from childhood and into adulthood (Fossum et al., 2021; Gordon & Hinshaw, 2020; Øie et al., 2021).

Since some evidence suggests that bilinguals outperform monolinguals in response times, reflecting attention control (Calabria et al., 2011), and bilingualism is notoriously associated with a cognitive advantage, it seems to be relevant also to investigate the cultural space that provides learning experiences for children to develop cognitive enhancement programs based on these findings, so that they become efficient adults.

### *1.1. Bilingualism and the attentional network*

Studies demonstrating the benefits of bilingualism in the growth of cognitive processes highlight how speaking two different languages involves the activation of continuous suppression processes for the language that is not being spoken at the time. This activity of constant selection and inhibition

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 May 2023 doi:10.20944/preprints202305.1319.v1



of the correct language appropriate to the context should lead to better training of the attentional networks and generate the advantage of being bilingual. According to Bialystok (2011), bilinguals have an advantage in executive functions (EF) because they constantly train to carry on a conversation based on the context and require continued access to the information in the working memory. Furthermore, choosing the correct language for the specific communicative situation (inhibiting the other language) and monitoring what happens during the interaction (cognitive flexibility) is necessary. It has been demonstrated that training can improve executive functions (Karbach & Kray, 2009; Moreno et al., 2011). This type of cognitive advantage is mainly reflected in tasks involving attentional networks (Costa et al., 2008; Dash et al., 2019).

According to Green's Joint Activation Model (1998), a bilingual person's brain would always be engaged in both languages, regardless of the language spoken at the given time. Therefore, it would be necessary to use a general suppression mechanism to inhibit the activation of the non-target language; monolinguals, by contrast, are not used this suppression.

According to a new wave of findings, however, the bilingual advantage is more evident in executive attention than inhibition. The influence of multilingual experience is limited to attentional disengagement rather than having an overall inhibitory effect, which is why it is visible in the sequential but not traditional congruency effect (Spinelli et al., 2022). Attentional disengagement is an aspect of executive attention that terminates attention to preceding stimuli and diminishes their impact on current processing. Some studies found that monolingual-bilingual differences were attenuated when groups were matched on general ability (Antón et al., 2014) or socioeconomic background (Morton & Harper, 2007). Therefore, conflict adaptation paradigms should allow easier detection of the bilingual advantage than simple interference paradigms (Spinelli et al., 2022). Bilinguals have much experience disengaging attention from prior stimuli due to the difficulties of managing two languages; as a result, they are relatively immune to the impact of previous stimuli on current processing. Contrarily, monolinguals are not. These findings concur with data that connects differences in conflict adaptation with differences in executive-attention processes, claim Grundy et al. (2017).

Paap et al. (2015) stated, "bilingual advantages in executive functioning either do not exist or are restricted to particular and undetermined circumstances." They pointed out that 80% of the tests after 2011 failed to obtain results supporting the bilingual effect. According to this view, the results of earlier research on this topic might be explained by the inability to control various external factors, such as the experimental tasks selected to assess it and the limited number of subjects included in the studies.

Socioeconomic status (SES) and the participants' cultural and linguistic backgrounds are other factors that play a role in determining these results. Low socioeconomic status leads to lower cognitive functioning (Rosen et al., 2019). Given the high frequency of low socioeconomic status and reduced vocabulary in bilinguals, several authors have highlighted the importance of analyzing these aspects and monitoring the effect of these variables if a statistically significant difference is observed between groups. Although many authors (e.g., Carlson and Meltzoff, 2008; Blom et al., 2014) considered that statistical control of these variables is the most appropriate approach, while others think that these conditions are a specific characteristic of the population of interest (Buac et al., 2016), it is mainly suppositional that discrepancies between monolinguals and bilinguals' socioeconomic status reflect variations in attentional disengagement (Spinelli et al., 2022; Goldsmith & Morton, 2018a; Goldsmith & Morton, 2018b).

A recent study by Orsolini et al. (2023) investigated the role of working memory in reading comprehension in Italian monolingual and bilingual children. The findings reveal that working memory facilitates reading comprehension only indirectly. Written text comprehension is frequently called a complex dual process in working memory. While simultaneously coordinating several information sources to limit the development of a text representation, pertinent semantic content is kept alive in short-term memory. Such a dual process would necessitate the central executive's direct involvement in reading comprehension, which does not appear to happen in elementary school students. Monolingual children's comprehension of an oral text was strongly associated with working memory ability; the main difference identified by this study is the absence of indirect WM effects on reading comprehension in bilinguals (Orsolini et al., 2023).

Bilinguals' need to continuously handle two languages while speaking may have a general impact on their attentional networks. Some studies reported that bilingualism leads to better executive control (Costa, Hernández & Sebastián-Gallés, 2008). The findings showed that multilingual participants were quicker at completing the task and more effective in the executive control and alerting networks. In particular, bilinguals benefited more from presenting an alerting cue and were more efficient at resolving conflicting information. Additionally, compared to monolinguals, bilinguals had lower switching costs between the various trial types. These findings show that bilingualism impacts young adults' ability to develop effective attentional processes when that ability is expected to be at its height.

Recent research by Park and colleagues (2019) demonstrated that executive control was not affected by bilingual experience and was worse in children with developmental language disorders (DLD) than in children with usual development. At least for children in this age range, dual language experience has little impact on these skills. The DLD group may have a bilingual advantage in terms of orientation.

When other factors (such as socioeconomic status, vocabulary knowledge, and age) are controlled, Tran, Arreondo, and Yoshida (2015) showed that culture significantly impacts the development of alerting and executive control attentional networks. In contrast, language status was only significant for the executive control attentional network.

*1.2. Attentional Network and socioeconomic status*

Socioeconomic status (SES) has already been found to impact attentional function significantly and, more specifically, attentional regulation.

For instance, children from low SES families frequently exhibit poor self-regulation (Buckner, Mezzacappa, & Beardslee, 2003), an index of executive control maturity. Measures of executive control also show that children of middle SES outperform their peers (Farah & Noble, 2005; Noble, Norman, & Farah, 2005). Also, it appears that the family's socioeconomic situation modifies the mechanism of attention disengagement, which is essential for developing attention regulation (Conejero & Rueda, 2018).

A study examined whether parental and adolescent stress mediated between socioeconomic status and adolescent executive functioning in urban youth and discovered that parent stress was directly related to adolescent stress. In contrast, adolescent stress was directly related to EF behavior components (i.e., emotion control, set-shifting, and inhibition) (Mance et al., 2019). More directly relevant to our study, Mezzacappa (2004) found that higher SES children were faster and more efficient in the alerting and conflict trials of the child ANT than lower SES children. Additionally, low SES—and precisely the low quality of the home environment—has been shown to indirectly Influence children's inhibitory control and sustained attention (National Institute of Child Health and Human Development Early Child Care Research Network,2003).

Thus, previous studies' lack of a systematic measure of SES may have led to overestimating the bilingual advantage. Ladas, Carrol, and Vivas (2015) found that the bilingual advantage is considerably reduced when monolingual and bilingual participants are carefully matched on SES.

Growing up in a bilingual environment is becoming increasingly common, the literature suggests a possible link between the environment and the neural correlates of attention, yet these remain unknown.

A low SES is associated with high-stress levels (Chen, Cohen, and Miller, 2010), and high-stress levels can alter cognitive functions, including selective attention.

Poor environments are often associated with factors that lead to chronic stress that can affect the individual's well-being (Santiago, Wadsworth, and Stump, 2011), and families with low SES most likely live in chaotic, noisy, and crowded environments.

Therefore, children living in a poor environment are more susceptible to psychosocial and physical stress; chaotic environments are unpredictable and inconsistent, and there is often a lack of routine, which can interfere with healthy development from childhood to adulthood (Evans et al., 2005).

How do bilingualism-related factors, such as the age of exposure to two languages, language usage, and proficiency, modulate brain connectivity? There is evidence in the literature that bilingualism alters the grey and white matter structure in the brain; for example, in adult studies, greater volume and grey matter density are found in regions associated with language, such as the bilateral inferior frontal gyrus (IFG), inferior parietal lobule, anterior cingulate cortex, caudate and putamen (Mechelli et al., 2004; Abutalebi et al., 2012).

A recent study that included a different group of highly competent bilingual individuals found the same link in the bilateral IFG. Additionally, the authors found that more excellent functional connectivity between cortical and subcortical brain regions, specifically between the left caudate and bilateral superior temporal gyrus and the anterior cingulate cortex and left putamen, was positively correlated with greater "diversity of language use" (i.e., an environment in which both languages are commonly used and segregated use of each language is not routine). (Gullifer et al., 2018). Overall, there is growing evidence that factors connected to bilingualism affect the functional connectivity of the brain. However, little is known about how these connectivity changes related to executive control' performance.

Also, there is emerging evidence that bilingualism affects the brain's gray and white matter organization. However, a recent study in preschoolers (aged between 3 and 5 years) found no structural alterations in the IFG but indications of more robust functional connectivity in bilinguals than in monolinguals, suggesting that structural changes may only manifest after continuous exposure to two languages (Thieba et al., 2019).

### *1.3. The study's aim*

In this work, we compared the performance of third, fourth, and fifth-grade bilingual and monolingual children in attentive and cognitive tasks. Participants were evaluated in an attentive task (ANT) that evaluates the networks of alert, orientation, and executive conflict, and in some tests of working memory, processing speed, and linguistic receptivity, also analysing the socio-status economic of families and the IQ.

The literature overview in the previous sections suggests that parents' socioeconomic status has a crucial influence on children's cognitive development. However, it is not clear whether this effect varies as a function of the children's multilingualism.

This study suggests that culture and bilingualism may interact to better explain previously observed advantages and the growing discrepancy surrounding cognitive benefits in bilingual literature.

## **2. Materials and Methods**

### *2.1. Procedure*

The Department of Developmental and Social Psychology at Sapienza University of Rome's Ethics Committee approved this study.

We contacted schools with a large multilingual student sample. One school interested in participating and located in a suburban area of Rome was selected. The school's principal, the children's teachers, and parents or guardians were informed with a letter detailing the project's aims and procedures. All the children in grades 3, 4, and 5 received parental consent and participated in the assessment sessions. All the assessment sessions took place inside the school building, in two special classrooms reserved for the project, on days and times, indicated by the teachers. If the child showed impatience or no longer wished to continue, the meeting was suspended and resumed another day. The teachers were intermediaries between parents and examiners in delivering a parents' questionnaire completed at home. All questionnaires were returned in a sealed envelope to guarantee privacy and anonymity. Data collection began in November 2019 and ended in early March

2020 due to the spread of COVID-19. For this reason, some children could not complete some tests and were excluded from the study.

### *2.2. Participants*

We recruited 135 students aged between 95.05 and 136.4 months (M:114,6 S.D.:8,48) attending a school on the outskirts of Rome with a high percentage of international students, and from a school in Naples.

The inclusion criteria for this study were that the children had not been diagnosed with neurodevelopmental disorders and had a score higher than 80 in the Raven's Coloured Progressive Matrices test. The participants' parents signed the informed consent and compiled the questionnaire that allowed the linguistic status (monolingual or bilingual) and socioeconomic status to be determined. To encourage children's participation, at the end of the test sessions, they were given diplomas with which the university certified their participation in the research. The two groups (monolingual and bilingual) did not significantly differ for nonverbal reasoning as expressed with z scores on the Raven's Coloured Progressive Matrices ($t(98) = .63$, $p < .52$, $d = .12$).

### *2.3. Participants' Sociocultural and Language Characteristics*

We investigated the sociocultural and economic status through a questionnaire addressed to children's parents.

The participants lived in a suburban area of Rome characterized by low or medium-low SES. Most children's parents had a medium-low level of education with the prevalence of a secondary school qualification (father 39,8%; mother 41,9%) or a middle school certificate (father 34,7%; mother 28,6%). Few parents had a college degree (father 7,1%; mother 9,2%). We measured the parent's level of education as the number of years at school after 5 years of age and added the years of education of the two parents in the analyses that controlled the influence of the parents' education on children's reading comprehension. The number of years at school doubled for the seven single-mother or father families. Monolingual and bilingual children did not differ significantly for their parent's level of education ($t(98) = -.99$, $p < .32$, $d = .20$)). We calculated the sociocultural index by assigning a score to the father's and mother's years of education and profession and adding these scores together.

The monolingual children had only been exposed to Italian at home. In the few cases where one or both parents were not Italian native speakers, they had lived in Italy for at least 10 years, reported that their dominant language at home was Italian and that their comprehension and production of Italian was very good; their questionnaire stated that the child had no, or very low, comprehension of the parent's L1.

Most bilingual children were born in Italy (89%), and the remainder had settled in Italy within their first 3 years. The bilingual children were exposed to an L1 different from Italian from birth and Italian from birth or before age 4. We included in this study only children whose parents reported that the child's comprehension of L1 was good or excellent.

#### 2.3.1. Assessment of IQ

The Raven's Progressive Matrices (RPM) test is a non-verbal test used to measure non-verbal reasoning, abstract reasoning, and cognitive functioning.

As Raven's Test is strictly visual, the issues of potential language barriers and religious/cultural affiliations are circumvented. Hence, Raven's Progressive Matrices test is one of the most common measures for general intelligence and is used by companies to deduce whether the interviewee has adequate cognitive skills for the job.

In the Raven's Progressive Matrices test, candidates are presented with a matrix that has a 3x3 geometric design, with one piece missing. The candidates' job is to choose the correct diagram from a set of eight answers that completes a pattern in the matrix. The questions and answers are entirely non-verbal, and the matrices differ in the cognitive capacity required to identify the correct answer.

2.3.2. Assessment of language abilities

The Peabody Picture Vocabulary Test (Dunn & Dunn, 2007) is one of the most commonly used assessment tests that measure verbal ability. It measures the receptive processing of examinees from 2 to over 90 years old. This measurement serves multiple purposes. The test is given verbally and takes twenty to thirty minutes to complete. The individual requires no reading, and the scoring is rapid. For its administration, the examiner presents a series of pictures to each person. A page has four pictures, each of which is numbered. The examiner says a word that describes one of the images and asks the person to point, or say, the number of the image the word describes. Depending on the age of the person being tested, item responses can also be made through multiple-choice selection. The total score can be converted to a percentile rank, mental age, or IQ score with standard deviation. Although it is preferred, no special training is required to administer and score the PPVT-IV. The test publisher recommends that anyone interpreting or explaining the test scores should know about psychological testing and statistics.

2.3.3. Assessment of Working memory

Non-Word repetition

This task is part of the Italian VAUMeLF battery (Bertelli & Bilancia, 2006) (Reliability: Cronbach's alpha= .90 to .99). The test consists of 40 pseudo-words presented via an audio track with an interval of 5 seconds. Each child's repetition was scored 1. The normative battery data converted the final raw score (maximum score: 40) into a zeta score.

The Working Memory Index (WMI)

The working memory index (WMI) was composed of two subtests from the Italian version of the fourth edition of the Wechsler Intelligence Scale for Children (Wechsler, 2003) (Reliability: Cronbach's alpha=.87 to.92): Digit Span (forward and backward) and Letter-Number Sequencing. Forward Digit Span requires the child to repeat numbers in the same order as read aloud by the examiner, whereas Backward Digit Span requires the child to repeat numbers in the opposite order as read aloud by the examiner; if the child incorrectly repeats two sequences of digits from the same item, the test is terminated. The Letter-number sequencing task involves hearing a series of letters and digits and then reporting the stimuli with the letters in alphabetical order and digits in ascending numerical order (e.g., 4-B-1-A→1-4-A-B). When a child scores 0 on three items, the task is interrupted. Using the WISC IV Italian normative data (Orsini, Pezzuti, Picone, 2012), the children's raw scores on (a) direct and backward digit span and (b) letter/number sequencing was first converted in scaled scores, and then their sum was converted into an IQ score.

Immediate narrative Memory

In this task drawn from the Nepsy II battery (Korkman, Kirk & Kemp, 2007) (Reliability: Cronbach's alpha= .69 to .71), the child is asked to listen to a short story and then to recall it immediately afterward (free recall score: 0-20). Credit is given for each correct retrieval of a story element, regardless of whether the recall is verbatim, expressed with a similar meaning, or in a different sequence than the story heard. Credit is given for each element of the story retrieved correctly, irrespective of whether the recall is verbatim, expressed with a similar meaning, or in a sequence different from the story heard. The test also requires the child to answer open questions for the details that have not been spontaneously retrieved (cued recall) and eventually answer closed questions (recognition score); only the free recall score has been used in the analyses of our study. This score- which taps into immediate memory retrieval- was converted to a scaled score (mean=10, st.dev.=3) using Nepsy II's Italian normative data (Urgesi, Campanella, &Fabbro, 2011).

2.3.4. Assessment of attentional networks

Apparatus

Stimuli were presented on a 12-inch color monitor. Responses were gathered with a standard computer mouse. A PC running E-Prime software controlled the presentation of the stimuli, timing operations, and data collection.

Stimuli

Each participant completed two versions of the ANT that differed only in the types of stimuli. An ANT version presented colored fish as target and flanker stimuli, just as described in Rueda et al. (2004). All participants also completed a new version of the ANT that presented photographs of faces instead of fish. The stimuli and procedure were the same as Federico et al. (2013) described.

*2.4. Procedure*

The experimental session consisted of two tasks: the fish version (ANT.Fish) and the face photographs version (ANT.Real-Face). Each task consisted of a practice block with 24 trials and two experimental blocks of 48 trials each. The order of each task was randomized across participants. The order of each task was randomized across participants. Participants could take breaks at the end of the practice block and among tasks.

The instructions were the same for all the versions of the task. Participants were told that a picture of a face (or a fish) would appear on the screen and that the purpose of the task was to press the button on the mouse that matched the direction the face was looking (or the fish was directed). Each target was preceded by a cue stimulus that either alerts or orients participants to the upcoming target. There were four cue types: no-cue (neither alerting nor orienting cue was presented), double-cue (a double-asterisks cue appearing simultaneously above and below fixation; alerting), spatial cue (a single asterisk presented in the position of the upcoming target; 100% predictive of the target location; orienting), or central cue (an asterisk presented at the location of the fixation cross). Measures of the efficiency of the three attentional networks were obtained via simple subtractions of reaction times between conditions. The so-called "conflict effect" was calculated by subtracting the congruent flanking conditions' mean reaction times (RTs) from the mean RTs of incongruent flanking conditions. The two conditions differ only in the information given by the flankers. When the images are congruent, they facilitate the discrimination of the target stimulus, whereas incongruent flankers distract participants. Visual cues are used to assess the orienting and alerting separately. The orienting effect was calculated by subtracting the mean RTs of the spatial-cue conditions from the mean RTs of the center-cue conditions. Both center and spatial cues alert the participant to the forthcoming appearance of the target. However, only the spatial cue provides spatial information, which allows participants to orient their attention to the appropriate spatial location. In the no-cue or double-cue conditions, attention tends to be diffused across the two potential target locations. Neither of these conditions provided spatial information about the target stimulus position, but the double-cue alerts the participant to the imminent appearance of the target. Therefore, the alerting effect was calculated by subtracting the mean RTs of the double-cue conditions from the mean RTs of the no-cue conditions. This represents the benefit of alerting on the speed of the response to the target (Fan et al., 2009; Fan et al., 2002; Federico et al., 2013; 2017; Martella, Casagrande, & Lupianez, 2011).

2.4.1. Parent's Questionnaire

The questionnaire for parents, "Lingue, Discorsi e Lettura" (Pirchio e Federico, 2019), investigated the socio-cultural and socio-linguistic condition of the participants.

The questionnaire investigated:

- general information about the child and his family;
- employment of parents and educational qualification;
- country of origin of parents and years of stay in Italy;
- languages are spoken at home;
- frequency of activities carried out with his/her child;
- linguistic competence in L1 and L2 (part reserved for parents with languages other than Italian).

Each child has been assigned an identification code to ensure anonymity and privacy.

The parent has been asked to indicate for each member of the family (mother, father, child, brothers/sisters) which language/s are/are not used in everyday life, being able to choose between three possible alternatives: only Italian, Italian, and other languages (specifying which), another language only (specifying which).

doi:10.20944/preprints202305.1319.v1



They also investigated the linguistic competence of the parents, asking them what their knowledge of the Italian language was; the assigned values are from 1 (not at all) to 4 (fluently).

The children's questionnaire was used to obtain information about the use of languages in the family, at school, and with friends or classmates.

2.4.2. Computation of attentional networks

Measures of the three attentional networks (alerting, orienting, executive control) efficiency were obtained by simple reaction times and subtractions between conditions. Alerting effect was calculated by subtracting the mean RTs of the double-cue conditions from the mean RTs of the no-cue conditions. This difference should evidence the speeding effect of alerting on responses. The orienting effect was calculated by subtracting the mean RTs of the spatial-cue conditions from the mean RTs of the central-cue conditions. Participants are alerted to the imminent appearance of the target by both central and spatial cues. However, only the spatial cue provides spatial information that orients their attention to the correct location. Executive control effect was calculated through the so-called "conflict effect" by subtracting the mean RTs of the congruent flanking conditions from the mean RTs of incongruent flanking conditions. When flankers were congruent, discrimination of the target stimulus was facilitated, whereas incongruent flankers distracted participants.

## 3. Results

*3.1. The linguistic and the sociocultural status*

We conducted a multivariate analysis of variance, with the linguistic status variable used as the between-group variable, the sociocultural status as a covariate, and all other variables used as within-group variables.

The results showed a significant difference between the two different linguistic statuses ($F_{15,120}$= 4,92 $p<0.0001$ $\eta 2$= 0.38) and the different sociocultural index ($F_{15,120}$= 4,92 $p<0.0001$ $\eta 2$= 0.38). Table 1 summarizes the means and the standard deviations of the different variables, and Table 2 shows the results of the within groups analysis.

**Table 1.** Means and the standard deviations.

| | **Bilingual** | | **Monolingual** | |
|---|---|---|---|---|
| | **Mean** | **St. deviation** | **Mean** | **St. deviation** |
| Raven's Progressive Matrices (Z scores) | -0,13 | 0,86 | -0,16 | 0,88 |
| Peabody Picture Vocabulary Test (Z scores) | 94,09 | 14,56 | 96,2 | 14,88 |
| Digit Span (Z scores) | 8,57 | 2,63 | 8,98 | 2,81 |
| Non-Word Repetition (Z scores) | -1,12 | 1,68 | -1,08 | 1,58 |
| Letter-Number Sequencing (Z scores) | 9,07 | 3,30 | 9,3 | 4,13 |
| Immediate Narrative Memory(Z scores) | 9,65 | 3,34 | 10,27 | 2,89 |
| Alerting Photo (rt) | 78,81 | 115,74 | 32,38 | 191,92 |
| Orienting Photo (rt) | 30,54 | 136,56 | 45,56 | 106,24 |
| Conflict Photo (rt) | 102,62 | 161,17 | 28,80 | 210,97 |

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 May 2023 doi:10.20944/preprints202305.1319.v1



| | | | | |
|---|---|---|---|---|
| Alerting Fish (rt) | 126,03 | 132,86 | 75,90 | 150,73 |
| Orienting Fish (rt) | 14,37 | 111,63 | 12,52 | 114,21 |
| Conflict Fish (rt) | 296,09 | 176,59 | 264,28 | 220,50 |

**Table 2.** Results of the within groups analysis.

| | **Linguistic status** | | | Sociocultural status | | |
|---|---|---|---|---|---|---|
| | **F** | **p** | **η²** | F | p | η² |
| Raven's Progressive Matrices | 0,04 | 0,843 | 0 | 0,367 | 0,546 | 0,003 |
| Peabody Picture Vocabulary Test | 51,166 | 0 | 0,276 | 0,018 | 0,895 | 0 |
| Non-Word Repetition | 0,043 | 0,837 | 0 | 0,762 | 0,384 | 0,006 |
| Digit Span | 0,043 | 0,837 | 0 | 0,079 | 0,779 | 0,001 |
| Letter-Number Sequencing | 0,783 | 0,378 | 0,006 | 0,231 | 0,632 | 0,002 |
| Immediate Narrative Memory | 1,744 | 0,189 | 0,013 | 1,235 | 0,268 | 0,009 |
| Alerting Photo | 3,386 | 0,068 | 0,025 | 4,086 | 0,045 | 0,03 |
| Orienting Photo | 0,436 | 0,51 | 0,003 | 1,633 | 0,204 | 0,012 |
| Conflict Photo | 5,194 | 0,024 | 0,037 | 13,756 | 0 | 0,093 |
| Alerting Fish | 5,183 | 0,024 | 0,037 | 11,34 | 0,001 | 0,078 |
| Orienting Fish | 0,018 | 0,893 | 0 | 1,013 | 0,316 | 0,008 |
| Conflict Fish | 1,052 | 0,307 | 0,008 | 4,03 | 0,047 | 0,029 |

Considering the linguistic status and the sociocultural index, the subjects showed different performances in the receptive language (Peabody), in the attentional network of alerting both with social and non-social stimuli and in the attentional network of conflict with non-social stimuli. The monolingual children showed better linguistic comprehension than bilingual children, and the bilingual children showed higher scores on alerting and conflict (Table 3; Figures 1 and 2).

**Table 3.** Results obtained by dividing the subject by levels of the sociocultural index.

| | **Low sociocultural status** | | High sociocultural status | |
|---|---|---|---|---|
| | **Mean** | St.dev | Mean | St.dev |
| Raven's Progressive Matrices (Z Score) | -0,31 | 0,89 | -0,06 | 0,85 |
| Peabody Picture Vocabulary Test | 94,09 | 14,56 | 96,2 | 14,88 |
| Digit Span | 8,57 | 2,63 | 8,98 | 2,81 |
| Non-Word Repetition | -1,12 | 1,69 | -1,09 | 1,61 |
| Letter-Number Sequencing | 9,07 | 3,30 | 9,3 | 4,13 |
| Immediate Narrative Memory | 9,65 | 3,34 | 10,27 | 2,89 |
| Alerting Photo | 63,98 | 111,51 | 54,16 | 175,51 |
| Orienting Photo | 58,05 | 144,81 | 27,040 | 110,34 |
| Conflict Photo | 6,49 | 176,11 | 100,11 | 187,90 |
| Alerting Fish | 142,48 | 149,81 | 83,01 | 136,00 |
| Orienting Fish | 20,83 | 110,49 | 9,82 | 113,80 |
| Conflict Fish | 334,65 | 195,81 | 254,58 | 194,48 |

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 May 2023 doi:10.20944/preprints202305.1319.v1



A difference is observed between bilingual and monolingual children in the Alert Network, with social and non-social stimuli, when the sociocultural status index is entered as a covariate (Figure 1 and 2).

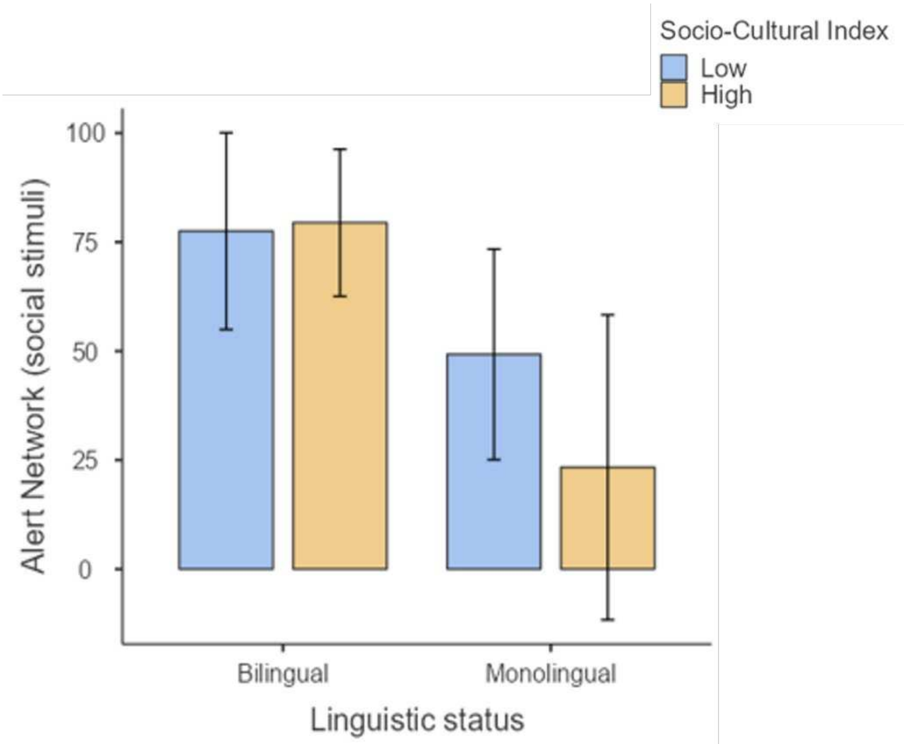


**Figure 1.** Results on Alert Network with social stimuli.

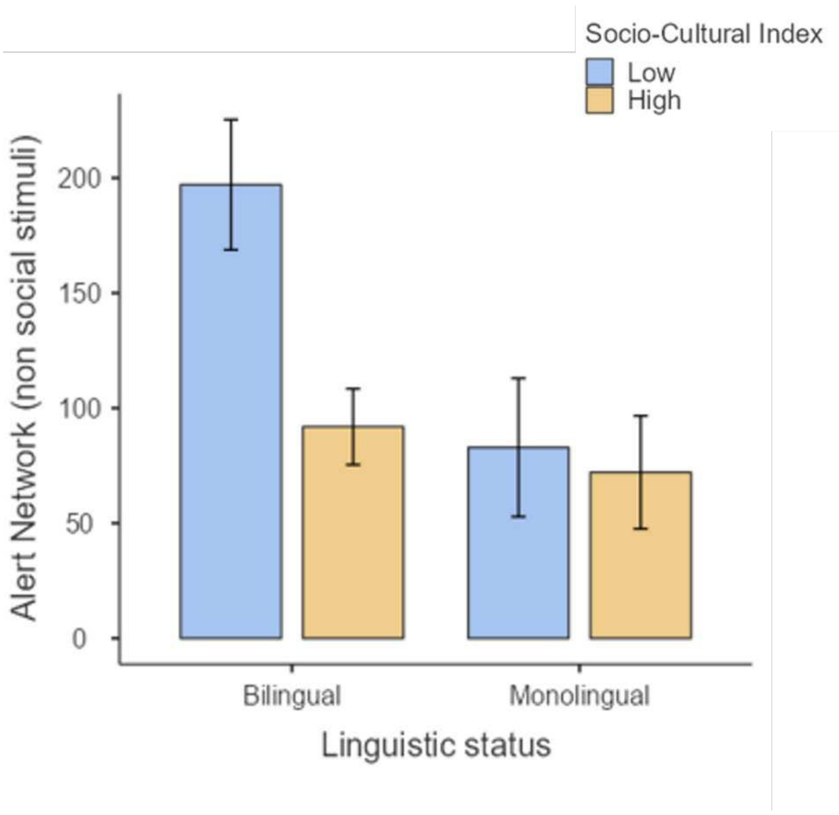


**Figure 2.** Results on Alert Network with no social stimuli.

Only the sociocultural index shows a difference between groups in the executive control network when non-social stimuli are used (Figure 3).

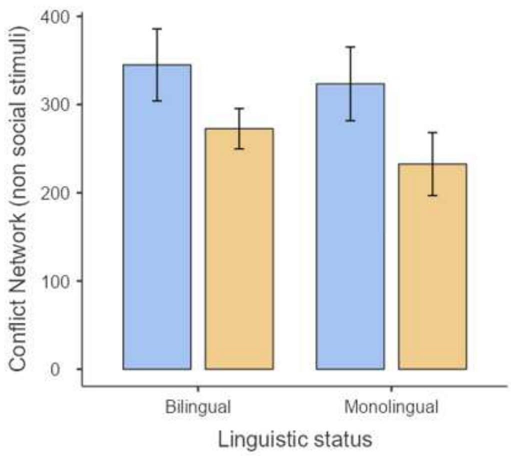


**Figure 3.** Results on Conflict Network with non-social stimuli.

## 4. Discussion

There is much controversy regarding whether bilinguals generally outperform monolinguals in terms of cognitive control while managing multiple languages (Bialystok et al., 2004; Paap & Greenberg, 2013).

According to a recent version of this theory, this advantage may be related to executive attention rather than inhibitory processes, as was previously believed (Bialystok, 2017). It would be easier to identify conflict-adaptation paradigms than simple interference paradigms (Grundy et al., 2017).

This study has examined whether linguistic status and the sociocultural context influence attentive networks. We also investigated if there is a difference in the elaboration of stimuli with social value and stimuli without social value by evaluating how this difference in stimuli influences the three functionally and anatomically distinct networks of alerting, orienting, and executive attention. As previously mentioned, alerting network is concerned with the ability to enhance sensitivity to incoming information and to maintain it, the orienting network manages the ability to select and focus on the stimulus that needs to be attended to, and the executive control network manages the ability to control behavior to achieve goals and resolve conflicts between alternative responses.

The Attention Network Test measures how exposure to stimuli that trigger or direct our attention speeds up and improves the accuracy of our behavioral responses. Further, matching or contrasting flanker stimuli with ANT can measure how much the environment can influence our attentional focus and capacity to ignore distractions. For these characteristics, ANT is suitable for studying alerting, orienting, and executive attention. In this context, Federico and collaborators (2013; 2017; 2021) have proven that exposure to real faces positively affected the efficiency of executive control. Using a modified version of the ANT - with three different types of stimuli: fishes, drawn faces, and faces' photographs- the authors demonstrated that exposure to social stimuli decreases cognitive interference and enhances the efficiency of executive control.

In our study, the reaction times of the two groups are similar in the experiment with social stimuli.

In contrast, in the experiment with non-social stimuli, in which both groups are faster than the previous condition, monolinguals are faster than bilinguals.

This result differs from previous research, in which bilingual children are faster than monolingual children (Costa, Hernandez, and Sebastián-Gallés, 2008; Kroll & Bialystok, 2013; Wimmer & Marx, 2014).

Interestingly, the linguistic status is related to the alert network both in the test with and without social stimuli.

On the other hand, the executive control network is only related to linguistic status in the case of testing with social stimuli.

In contrast, the sociocultural index shows a relation only in the alert network with non-social stimuli and in the executive control with non-social stimuli.

To better understand the effects, we have seen what happens in the alert network in monolingual and bilingual children by dividing them according to their families' sociocultural status.

We observe a moderation of sociocultural status in monolingual children's performances when the test uses social stimuli. The same result is found in bilingual children when considering the test with non-social stimuli.

Examining the relationships between the different variables considered, interestingly, neither the sociocultural index nor the linguistic status nor the attentional network correlates with working memory functioning. This finding aligns with recent meta-analyses that claim no correlation suggests absent or weak associations between bilingualism and WM capacity (Lehtonen et al., 2018; Monnier et al., 2021; see Grundy & Timmer, 2017).

Also, Orsolini and colleagues had similar results in a recent study (2023) investigating reading comprehension in monolingual and bilingual children. Monolingual children's comprehension of an oral text was strongly associated with working memory ability; the main difference identified is the absence of indirect WM effects on reading comprehension in bilinguals (Orsolini et al., 2023).

Most importantly, because executive attention has historically been closely linked to WM ability, this result raises questions about the assumption that being multilingual improves executive attention and that learning a second language would expand working memory's capacity (Engle, 2002; Kane et al., 2007).

We can conclude that bilingualism and sociocultural status affect attentive networks; the differences are observed between bilingual and monolingual children in both alert and executive control networks when social stimuli are used, and the effect of sociocultural status is controlled.

Only the sociocultural status highlights differences between linguistic groups in the executive control network with non-social stimuli.

## 5. Conclusions

According to our results, both bilingualism and sociocultural status affect attentive networks. In addition, we demonstrate that different stimuli affect attentive performance depending on whether they are stimuli with social connotations or not.

A study like ours could contribute to scientific research on social attention engagement in children. Further research could focus on implementing these abilities in training protocols and specific attention profiles.

## References

1. Abutalebi, J, Della Rosa, P.A., Green, D.W., Hernandez, M., Scifo, P., Keim, R., Cappa, S.F., Costa, A. (2012). Bilingualism tunes the anterior cingulate cortex for conflict monitoring. Cereb Cortex. Sep;22(9):2076-86. doi: 10.1093/cercor/bhr287. Epub 2011 Oct 29. PMID: 22038906.
2. Antón, E., Duñabeitia, J.A., Estévez, A., Hernández, J.A., Castillo, A., Fuentes, L.J. et al. (2014). Is there a bilingual advantage in the ANT task? evidence from children. Frontiers in Psychology, 5, 398. https://doi.org/10.3389/fpsyg.2014.00398
3. Barkley, R.A., Fischer, M.(2011). Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: self-reported executive function (EF) deficits versus EF tests. Dev Neuropsychol.;36(2):137-61. doi: 10.1080/87565641.2010.549877. PMID: 21347918.
4. Bertelli, B. & Bilancia, G.(2006). Batterie per la Valutazione dell'Attenzione Uditiva e della Memoria di Lavoro Fonologica nell'Età Evolutiva (VAUMeLF)
5. Bialystok E. (2011). Reshaping the mind: the benefits of bilingualism. Can J Exp Psychol. Dec;65(4):229-35. doi: 10.1037/a0025406. Epub 2011 Sep 12. PMID: 21910523; PMCID: PMC4341987.

6. Blom, E., Küntay, A.C., Messer, M., Verhagen, J., Leseman, P.(2014). The benefits of being bilingual: working memory in bilingual Turkish-Dutch children. J Exp Child Psychol. Dec;128:105-19. doi: 10.1016/j.jecp.2014.06.007. Epub 2014 Aug 20. PMID: 25160938
7. Buac M, Gross M, Kaushanskaya M. Predictors of processing-based task performance in bilingual and monolingual children. J Commun Disord. 2016 Jul-Aug;62:12-29. doi: 10.1016/j.jcomdis.2016.04.001. Epub 2016 Apr 20. PMID: 27179914; PMCID: PMC5041596.
8. Buckner JC, Mezzacappa E, Beardslee WR. Characteristics of resilient youths living in poverty: the role of self-regulatory processes. Dev Psychopathol. 2003 Winter;15(1):139-62. doi: 10.1017/s0954579403000087. PMID: 12848439.
9. Calabria, M., Branzi, F., Marne, P., Hernández, M., & Costa, A. (2015). Age-related effects over bilingual language control and executive control. Bilingualism: Language and Cognition, 18(1), 65-78. doi:10.1017/S1366728913000138
10. Carlson SM, Meltzoff AN. Bilingual experience and executive functioning in young children. Dev Sci. 2008 Mar;11(2):282-98. doi: 10.1111/j.1467-7687.2008.00675.x. PMID: 18333982; PMCID: PMC3647884.
11. Catherine Monnier, Julie Boiché, Pauline Armandon, Sophie Baudoin & Stéphanie Bellocchi (2022) Is bilingualism associated with better working memory capacity? A meta-analysis, International Journal of Bilingual Education and Bilingualism, 25:6, 2229-2255, DOI: 10.1080/13670050.2021.1908220
12. Chen, E., Cohen, S., & Miller, G. E. (2010). How Low Socioeconomic Status Affects 2-Year Hormonal Trajectories in Children. Psychological Science, 21(1), 31–37. https://doi.org/10.1177/0956797609355566
13. Conejero Á, Rueda MR. Infant temperament and family socio-economic status in relation to the emergence of attention regulation. Sci Rep. 2018 Jul 25;8(1):11232. doi: 10.1038/s41598-018-28831-x. PMID: 30046121; PMCID: PMC6060120.
14. Costa A, Hernández M, Sebastián-Gallés N. Bilingualism aids conflict resolution: evidence from the ANT task. Cognition. 2008 Jan;106(1):59-86. doi: 10.1016/j.cognition.2006.12.013. Epub 2007 Feb 2. PMID: 17275801
15. Dash, S., Shakyawar, S.K., Sharma, M. et al. Big data in healthcare: management, analysis and future prospects. J Big Data 6, 54 (2019). https://doi.org/10.1186/s40537-019-0217-0
16. Davis, J. L., & Matthews, R. N. (2010). NEPSY-II Review: Korkman, M., Kirk, U., & Kemp, S. (2007). NEPSY—Second Edition (NEPSY-II). San Antonio, TX: Harcourt Assessment. Journal of Psychoeducational Assessment, 28(2), 175–182 https://doi.org/10.1177/0734282909346716
17. DeCarlo Santiago, C., Wadsworth, M. E., & Stump, J. (2011). Socioeconomic status, neighborhood disadvantage, and poverty-related stress: Prospective effects on psychological syndromes among diverse low-income families. *Journal of Economic Psychology*, *32*(2), 218–230. https://doi.org/10.1016/j.joep.2009.10.008
18. Hicham El Costa, Julie Tabiasco, Alain Berrebi, Olivier Parant, Maryse Aguerre-Girr, Marie-Pierre Piccinni, Philippe Le Bouteiller, (2009). Effector functions of human decidual NK cells in healthy early pregnancy are dependent on the specific engagement of natural cytotoxicity receptors, Journal of Reproductive Immunology, Volume 82, Issue 2, 2009, Pages 142-147, ISSN 0165-0378, https://doi.org/10.1016/j.jri.2009.06.123.
19. Dunn, L. M., & Dunn, D. M. (2007). Peabody Picture Vocabulary Test--Fourth Edition (PPVT-4) [Database record]. APA PsycTests. https://doi.org/10.1037/t15144-000
20. Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science, 11*(1), 19–23. https://doi.org/10.1111/1467-8721.00160
21. Evans J, Heron J, Lewis G, Araya R, Wolke D; ALSPAC study team. Negative self-schemas and the onset of depression in women: longitudinal study. Br J Psychiatry. 2005 Apr;186:302-7. doi: 10.1192/bjp.186.4.302. PMID: 15802686.
22. Fan J, McCandliss BD, Sommer T, Raz A, Posner MI. Testing the efficiency and independence of attentional networks. J Cogn Neurosci. 2002 Apr 1;14(3):340-7. doi: 10.1162/089892902317361886. PMID: 11970796.
23. Fan, J., M. Ovtchinnikov, J. Comstock, S. A. McFarlane, and A. Khain (2009), Ice formation in Arctic mixed-phase clouds: Insights from a 3-D cloud-resolving model with size-resolved aerosol and cloud microphysics, J. Geophys. Res., 114, D04205, doi:10.1029/2008JD010782.
24. Federico, F., Marotta, A., Martella, D. and Casagrande, M. (2017), Development in attention functions and social processing: Evidence from the Attention Network Test. Br J Dev Psychol, 35: 169-185. https://doi.org/10.1111/bjdp.12154
25. Fossum, I. N., Andersen, P. N., Øie, M. G., & Skogli, E. W. (2021). Development of executive functioning from childhood to young adulthood in autism spectrum disorder and attention-deficit/hyperactivity disorder: A 10-year longitudinal study. Neuropsychology. https://doi.org/10.1037/neu0000768
26. Federico, F., Marotta, A., Adriani,T, Maccari, L., Casagrande, M., (2013). Attention network test — The impact of social information on executive control, alerting and orienting, Acta Psychologica, Volume 143, Issue 1, 2013, Pages 65-70, ISSN 0001-6918, https://doi.org/10.1016/j.actpsy.2013.02.006.

27. Federico, F., Marotta, A., Orsolini, M., & Casagrande, M. (2021). Aging in cognitive control of social processing: evidence from the attention network test. Neuropsychology, development, and cognition. Section B, Aging, neuropsychology and cognition, 28(1), 128–142. https://doi.org/10.1080/13825585.2020.1715336
28. Goldsmith, S. F., & Morton, J. B. (2018a). Time to disengage from the bilingual advantage hypothesis. *Cognition, 170,* 328–329. https://doi.org/10.1016/j.cognition.2017.09.011
29. Goldsmith, S. F., & Morton, J. B. (2018b). Sequential congruency effects in monolingual and bilingual adults: A failure to replicate Grundy et al.(2017). Frontiers in Psychology, 9, 2476.
30. Gordon, C. T., & Hinshaw, S. P. (2020). Executive Functions in Girls With and Without Childhood ADHD Followed Through Emerging Adulthood: Developmental Trajectories. Journal of Clinical Child & Adolescent Psychology, 49(4), 509–523. https://doi.org/10.1080/15374416.2019.1602840
31. Green, D.W. (1998). Mental control of the bilingual lexico-semantic system. Bilingualism: Language and Cognition, 1, 67–81. https://doi.org/10.1017/S1366728998000133
32. Grundy, J. G., & Timmer, K. (2017). Bilingualism and working memory capacity: A comprehensive meta-analysis. Second Language Research, 33(3), 325–340. https://doi.org/10.1177/0267658316678286
33. Grundy, J.G., Chung-Fat-Yim, A., Friesen, D.C., Mak, L. & Bialystok, E. (2017) Sequential congruency effects reveal differences in disengagement of attention for monolingual and bilingual young adults. Cognition, 163, 42–55.
34. Gullifer JW, Chai XJ, Whitford V, Pivneva I, Baum S, Klein D, Titone D. Bilingual experience and resting-state brain connectivity: Impacts of L2 age of acquisition and social diversity of language use on control networks. Neuropsychologia. 2018 Aug;117:123-134. doi: 10.1016/j.neuropsychologia.2018.04.037. Epub 2018 May 1. PMID: 29727624; PMCID: PMC6086747.
35. Hernàndez M, Caño A, Costa A, Sebastián-Gallés N, Juncadella M, Gascón-Bayarri J. Grammatical category-specific deficits in bilingual aphasia. Brain Lang. 2008 Oct;107(1):68-80. doi: 10.1016/j.bandl.2008.01.006. Epub 2008 Feb 21. PMID: 18294684.
36. Kane MJ, Brown LH, McVay JC, Silvia PJ, Myin-Germeys I, Kwapil TR. For whom the mind wanders, and when: an experience-sampling study of working memory and executive control in daily life. Psychol Sci. 2007 Jul;18(7):614-21. doi: 10.1111/j.1467-9280.2007.01948.x. PMID: 17614870.
37. Kray J, Kipp KH, Karbach J. The development of selective inhibitory control: the influence of verbal labeling. Acta Psychol (Amst). 2009 Jan;130(1):48-57. doi: 10.1016/j.actpsy.2008.10.006. Epub 2008 Dec 12. PMID: 19084817.
38. Kroll JF, Bialystok E. Understanding the Consequences of Bilingualism for Language Processing and Cognition. J Cogn Psychol (Hove). 2013;25(5):10.1080/20445911.2013.799170. doi: 10.1080/20445911.2013.799170. PMID: 24223260; PMCID: PMC3820916.
39. Ladas AI, Carroll DJ, Vivas AB. Attentional processes in low-socioeconomic status bilingual children: are they modulated by the amount of bilingual experience? Child Dev. 2015 Mar-Apr;86(2):557-78. doi: 10.1111/cdev.12332. Epub 2015 Jan 8. PMID: 25571905.
40. Lehtonen M, Soveri A, Laine A, Järvenpää J, de Bruin A, Antfolk J. Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. Psychol Bull. 2018 Apr;144(4):394-425. doi: 10.1037/bul0000142. Epub 2018 Mar 1. PMID: 29494195.
41. M.L. Rosen, M.P. Hagen, Lucy Lurie, Miles A, E. Zoe, Margaret A. Sheridan, Andrew N. Meltzoff, K.A. McLaughlin Cognitive stimulation as a mechanism linking socioeconomic status with executive function: a longitudinal investigation of the gap in academic achievement, Child Dev. (2019)
42. M.Rosario Rueda, Jin Fan, Bruce D McCandliss, Jessica D Halparin, Dana B Gruber, Lisha Pappert Lercari, Michael I Posner, Development of attentional networks in childhood, Neuropsychologia, Volume 42, Issue 8, 2004, Pages 1029-1040, ISSN 0028-3932, https://doi.org/10.1016/j.neuropsychologia.2003.12.012.
43. Mance GA, Grant KE, Roberts D, Carter J, Turek C, Adam E, Thorpe RJ Jr. Environmental stress and socioeconomic status: Does parent and adolescent stress influence executive functioning in urban youth? J Prev Interv Community. 2019 Oct-Dec;47(4):279-294. doi: 10.1080/10852352.2019.1617386. Epub 2019 Jun 6. PMID: 31169069; PMCID: PMC6849391.
44. Marina C. Wimmer, Christina Marx, Inhibitory processes in visual perception: A bilingual advantage, Journal of Experimental Child Psychology, Volume 126, 2014, Pages 412-419, ISSN 0022-0965, https://doi.org/10.1016/j.jecp.2014.03.004.
45. Martella D, Casagrande M, Lupiáñez J. Alerting, orienting and executive control: the effects of sleep deprivation on attentional networks. Exp Brain Res. 2011 Apr;210(1):81-9. doi: 10.1007/s00221-011-2605-3. Epub 2011 Mar 10. PMID: 21390488.
46. Mechelli A, Crinion JT, Noppeney U, O'Doherty J, Ashburner J, Frackowiak RS, Price CJ. Neurolinguistics: structural plasticity in the bilingual brain. Nature. 2004 Oct 14;431(7010):757. doi: 10.1038/431757a. PMID: 15483594

47. Mezzacappa E. Alerting, orienting, and executive attention: developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children. Child Dev. 2004 Sep-Oct;75(5):1373-86. doi: 10.1111/j.1467-8624.2004.00746.x. PMID: 15369520.
48. Morton JB, Harper SN. What did Simon say? Revisiting the bilingual advantage. Dev Sci. 2007 Nov;10(6):719-26. doi: 10.1111/j.1467-7687.2007.00623.x. PMID: 17973787.
49. Morton JB, Harper SN. What did Simon say? Revisiting the bilingual advantage. Dev Sci. 2007 Nov;10(6):719-26. doi: 10.1111/j.1467-7687.2007.00623.x. PMID: 17973787.
50. NICHD Early Child Care Research Network. (2002). Early Child Care and Children's Development Prior to School Entry: Results from the NICHD Study of Early Child Care. American Educational Research Journal, 39(1), 133–164. http://www.jstor.org/stable/3202474
51. Noble KG, Norman MF, Farah MJ. Neurocognitive correlates of socioeconomic status in kindergarten children. Dev Sci. 2005 Jan;8(1):74-87. doi: 10.1111/j.1467-7687.2005.00394.x. PMID: 15647068.
52. Noble KG, Norman MF, Farah MJ. Neurocognitive correlates of socioeconomic status in kindergarten children. Dev Sci. 2005 Jan;8(1):74-87. doi: 10.1111/j.1467-7687.2005.00394.x. PMID: 15647068.
53. Øie, M. G., Sundet, K., Haug, E., Zeiner, P., Klungsøyr, O., & Rund, B. R. (2021). Cognitive Performance in Early-Onset Schizophrenia and Attention-Deficit/Hyperactivity Disorder: A 25-Year Follow-Up Study. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.606365
54. Orsini, A., Pezzuti, L., Picone, L. (2012). WISC-IV. Contributo alla taratura italiana. Firenze: Giunti O.S.
55. Orsolini M, Federico F, Vecchione M, Pinna G, Capobianco M, Melogno S. How Is Working Memory Related to Reading Comprehension in Italian Monolingual and Bilingual Children? Brain Sciences. 2023; 13(1):58. https://doi.org/10.3390/brainsci13010058
56. 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.
57. Park, J., Miller, C.A., Sanjeevan, T., Van Hell, J.G., Weiss, D.J. &Mainela-Arnold, E. (2019) Bilingualism and attention in typicallydeveloping children and children with developmental languagedisorder.Journal of Speech, Language, and Hearing Research,62(11), 4105–4118
58. Pirchio S, Federico F. Lingue, Discorsi e Lettura (2019). 58. Spinelli, G., Goldsmith, S. F., Lupker, S. J., & Morton, J. B. (2022). Bilingualism and executive attention: Evidence from studies of proactive and reactive control. Journal of Experimental Psychology: Learning, Memory, and Cognition, 48(6), 906–927. https://doi.org/10.1037/xlm0001095
59. Stern S, Kirst C, Bargmann CI. Neuromodulatory Control of Long-Term Behavioral Patterns and Individuality across Development. Cell. 2017 Dec 14;171(7):1649-1662.e10. doi: 10.1016/j.cell.2017.10.041. Epub 2017 Nov 30. PMID: 29198526.
60. Sylvain Moreno, Deanna Friesen, Ellen Bialystok; Effect of Music Training on Promoting Preliteracy Skills: Preliminary Causal Evidence. *Music Perception* 1 December 2011; 29 (2): 165–172. doi: https://doi.org/10.1525/mp.2011.29.2.165
61. Tamm, L., Loren, R. E. A., Peugh, J., & Ciesielski, H. A. (2021). The Association of Executive Functioning With Academic, Behavior, and Social Performance Ratings in Children With ADHD. Journal of Learning Disabilities, 54(2), 124–138. https://doi.org/10.1177/0022219420961338
62. Thieba, Camilia & Long, Xiangyu & Dewey, Deborah & Lebel, Catherine. (2018). Young children in different linguistic environments: A multimodal neuroimaging study of the inferior frontal gyrus. Brain and Cognition. 134. 10.1016/j.bandc.2018.05.009.
63. Tran, C. D., Arredondo, M. M., & Yoshida, H. (2015). Differential effects of bilingualism and culture on early attention: A longitudinal study in the U.S., Argentina, and Vietnam. *Frontiers in Psychology, 6,* Article 795. https://doi.org/10.3389/fpsyg.2015.00795
64. Wechsler, D. (2003). Wechsler intelligence scale for children (4th ed.). San Antonio, TX: The Psychological Corporation