

## Article

# RETRACTED: Executive Functions and Foreign Language Learning

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**Abstract:** Executive functions (EFs) serve as an umbrella term to describe a set of higher-order cognitive abilities that include working memory, inhibitory control, cognitive flexibility, planning, reasoning, and problem-solving. Various studies suggest that foreign language learning likely promotes executive functions, but others suggest that executive functions could improve foreign language learning. The aim of this study is to investigate the relationship between executive functions and foreign language learning and how these processes could interact. The sample included 64 children from kindergarten, aged 4–5 years, with no documented neuropsychiatric disorders, and from the middle–high literacy group. They were divided into three groups based on the level of their knowledge of the foreign language. A significant effect of the group on the executive tasks is shown in the comparison of the groups. Children who belonged to a group that had advanced foreign language proficiency had better results in executive tasks. Our results suggest that the higher the level of foreign language proficiency, the higher the performance of the executive tasks. However, we do not know if there is a causal effect between these variables.

**Keywords:** executive function; foreign language; learning



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## 1. Introduction

Executive functioning refers to several cognitive abilities that enable and drive adaptive, goal-oriented behavior. It refers to the ability to generate thoughts, to think flexibly, and to update and manipulate information [1]. Executive functions (EFs) serve as an umbrella term to describe a set of higher-order cognitive abilities that are necessary to inhibit what is irrelevant to current goals, to self-monitor, and to plan and adjust behavior as appropriate to the context [1,2]. EFs are described as a complex set of cognitive abilities that include working memory, inhibitory control, cognitive flexibility, planning, reasoning, and problem-solving [3,4]. The prefrontal cortex (PFC) is the brain region most associated with EFs regarding the neuroanatomical basis of these functions [5]. In addition, Broca's area is interposed between the dorsolateral PFC (DLPFC) and the ventral portion of the premotor cortex. This region is concerned in the abstract mediation of the verbal expression of language [6]. It suggests that areas involved in EFs are connected to areas involved in verbal processes. Recent studies examining the relationship between language and executive functions have found correlations between the two. One of the most recent and relevant models for conceptualizing the relationship between EFs and habit systems is the Hierarchical Competing Systems Model or HCSM [7]. This model suggests that children have a habit system influenced by past experiences, and a representational system influenced by conscious reflection on behavior. The reflective system refers to the part of the brain that is guided by language. It is considered to be more developed than the habitual system, which is normally guided by the senses. This means that the reflective system can

override the habitual system when it comes to deciding how to act. Therefore, it is possible for the habitual system to lead an individual to be influenced by outside information. However, the reflective system can override this and instead guide more mature goal-directed behaviors. This could be explained by the model of the brain pointed out above, which indicates a correlation between language and other executive functions as the person ages. Furthermore, HCSM has led to the hypothesis that better syntactic skills, vocabulary and pragmatic language skills will improve performance on executive function tasks [8].

Moreover, other studies suggest the involvement of EFs in language skills. According to Miyake and colleagues [9], it could be possible that shifting plays a role in monitoring the progression of conversations. In addition, inhibition of competing words may be important during verbal production and comprehension [10,11]. Furthermore, understanding and production of words may require a multistage process involving three specific executive functions. This would be similar to the theories of other researchers, who stated that words require three stages of processing. These included the theories of Mozeiko and colleagues [12].

Various studies suggest that foreign language learning likely promotes EFs [13]. Other authors have suggested that bilingualism has beneficial effects on executive functions: language control mechanisms involved in comprehension and production processes contribute to domain-general executive control performance. This suggests a monitoring mechanism that connects executive functions and bilingual language control during comprehension and production [14]. Despite this, there is still a debate in the literature about the relationship between learning a second language and the performance of cognitive tasks [15]. A review of the literature reveals that some data strongly tended toward this form of a bilingual advantage whereas most current data clearly contest these findings. Perhaps bilingual advantages in young adulthood occur only when processing demands are highest [15]. Moreover, others suggest that bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances due to the lack of strong results in terms of behavioral and neurophysiological measurements [16]. In conclusion, the aim of this study is to investigate the relationship between executive functions and foreign language learning and how these processes interact to reveal if there is any correlation between them.

## **2. Materials and Methods**

### **2.1. Participants**

The sample for this study was chosen from an Italian kindergarten (Caserta) consisting of 66 children between the ages of 4 and 5. No specific mental health conditions were required; the only condition was being from a middle-class cultural group. These children were assessed using the Economic Scale, Social Scale–SES [17] to determine their cultural class. There were 33 female children and 33 male children in the sample; they had an average age of 4.4 (SD 0.51) and an average SES of 7.2 (SD 0.59). In collaboration with the Italian Foundation for Neuroscience and Developmental Disorders, qualified psychologists collected data at the DRC of the University of International Studies in Rome. The children were studied by psychologists, who collected data on their language abilities. These data were collected over a 10-week period, with children being exposed to Italian and English teaching for 2 h per day for 10 h per week. Additionally, these children were encouraged to learn English by having it taught in English. After school, the children involved in the project were of Italian parents. They would participate in projects that involved their senses, motor skills and construction in a laboratory. Additionally, they would also participate in group and individual games, as well as other manual activities.

Teachers were all compliant with teaching activity and specialized in innovative teaching of foreign languages (specifically English).

### **2.2. Protocol**

The protocol used for the evaluation of the inclusion criteria and the management of the study consists of the following tests: the McArthur Vocabulary subscale in the English

version [18] for the assessment of language skills for the English language; the WPPSI-IV [19,20] divided in: Total Intelligence Quotient (IQ), Primary Index Scales and Ancillary Index Scales for measuring cognitive development in preschoolers and young children.

*SES*: self-administered questionnaire aimed at collecting socio-economic data useful for the homogeneity of the sample.

*The MacArthur–Bates CDI*: a questionnaire given to parents designed to assess the communication skills of developing children from “the first signs of understanding, their first non-verbal gestural signals, the expansion of primitive vocabulary and the beginnings of grammar” [16]. Two separate forms have been developed: the CDI-Words and Gestures and the CDI-Words and Phrases. The CDI: Words and Gestures of MacArthur–Bates is designed for the development of children aged 8 to 18 months as a measure of emerging receptive and expressive vocabulary. The form MacArthur–Bates CDI: Words and Phrases is intended to evaluate only the expressive language.

*WPPSI- IV*: is the latest edition of an early childhood intelligence test. It is divided into two distinct age bands (2 years, 6 months to 3 years, 11 months and 4 years, 0 months to 7 years, 7 months) corresponding to different subtest batteries. The battery consists of 7 or 15 subtests; in the younger age group there are 5 subtests to determine the overall IQ, in the older age group there are 6 subtests. The factors are involved in ability such as processing speed, working memory, fluid reasoning, comprehension, etc. The scoring of these indexes was based on the conversion of raw scores into weighted scores and then into index scores age-based on the Italian sample.

### 2.3. Procedures

After a careful evaluation of the inclusion criteria for all children, WPPSI-IV was administered, and McArthur was compiled by teachers in the English form (short form) with the different subscales. Following the data collection, we investigated whether there were correlations between the WPPSI-IV subscales (the scoring of: VCI, verbal comprehension index; PRI, perceptual reasoning index; WMI, working memory index; PSI, processing information speed index; IQ, intellectual quotient) for the assessment of the executive functions and the form MacArthur–Bates CDI: Words and Phrases for the assessment of language skills for the English language. Moreover, the sample was divided into three groups based on the scoring of the MacArthur–Bates CDI: Elementary level (Gr1) composed of 22 children (12 males and 10 females) with an average SES of 7.29 (SD 0.57) and an average score on the MacArthur–Bates CDI of 66.7 (SD 4.32); Intermediate level (Gr2) composed by 22 children (13 males and 9 females) with an average SES of 7.32 (SD 0.49) and an average score on the MacArthur–Bates CDI of 102.8 (SD 5.70); Advanced level (Gr3) composed by 22 children (11 males and 11 females) with an average SES of 7.26 (SD 0.61) and an average score on the MacArthur–Bates CDI of 149.4 (SD 4.84).

### 2.4. Methods

Data analysis was performed using SPSS 26.0 statistical survey software (2019). We performed the analysis of variance (ANOVA) test. Significance at the level of 5% ( $\alpha < 0.001$ ) has been accepted. Finally, it was possible to investigate the factors of WPPSI-IV (the Working Memory Index and the Processing Speed Index) with the subscales of McArthur (the form MacArthur–Bates CDI: Words and Phrases-English version) that divided the sample into the three groups.

## 3. Results

The data analysis was performed using the statistical survey software SPSS 26.0. (2019). Significance at the level of 5% ( $\alpha < 0.001$ ) has been accepted. To determine how well the groups performed on the WPPSI-IV indices, an analysis of variance (ANOVA) test was performed. This involved comparing the group’s scores to the factors’ values, which were derived from the WPPSI-IV. These were then evaluated against the following indices: VCI, PRI, WMI, PSI,

and IQ. In addition, we performed a multivariate analysis of variance (MANOVA) to compare the individual indices in all three groups and observe any significant effects.

The WPPSI-IV factors showed a significant difference between the three groups. Additionally, the factors were significantly affected by the group: WMI [ $F(2,63) = 62.095$ ,  $p < 0.001$ ], PSI [ $F(2,63) = 14.626$ ,  $p < 0.001$ ] and IQ [ $F(2,63) = 23.693$ ,  $p < 0.001$ ] (Table 1).

**Table 1.** Comparison of indices between Group 1, Group 2, and Group 3.

| Factors | G1    |      | G2     |      | G3     |      | F      | p      |
|---------|-------|------|--------|------|--------|------|--------|--------|
|         | Means | SD   | Means  | SD   | Means  | SD   |        |        |
| VCI     | 98.36 | 5.00 | 101.54 | 6.20 | 102.36 | 6.69 | 2.722  | 0.073  |
| PRI     | 99.90 | 7.21 | 102.04 | 5.84 | 103.09 | 4.71 | 1.600  | 0.210  |
| WMI     | 83.54 | 5.52 | 95.50  | 4.31 | 98.22  | 5.04 | 62.095 | 0.00 * |
| PSI     | 90.86 | 6.44 | 97.81  | 5.25 | 99.72  | 5.39 | 14.626 | 0.00 * |
| IQ      | 89.04 | 6.49 | 99.63  | 6.74 | 103.72 | 8.49 | 23.693 | 0.00 * |

\* Statistical significance  $p < 0.001$  VCI: Verbal comprehension index; PRI: Perceptual reasoning index; WMI: working memory index; PSI: processing information speed index; IQ: Intellectual quotient.

Bonferroni post hoc tests were performed to check our hypothesis.

These analyses showed that the scores of Group 1 differ significantly from those of Group 2 in the following factors: WMI [ $-12.95$ ,  $p < 0.001$ ], PSI [ $-6.95$ ,  $p < 0.001$ ] and IQ [ $-10.59$ ,  $p < 0.001$ ] demonstrating that prolonged exposure to a learning environment with the use of activities in a second language is related to a greater development of executive functions (Table 2).

**Table 2.** Post hoc comparisons between Groups 1 and 2.

| Factors | G1    |      | G2     |      | Differences | p       |
|---------|-------|------|--------|------|-------------|---------|
|         | Means | SD   | Means  | SD   |             |         |
| VCI     | 98.36 | 5.00 | 101.54 | 6.20 | -3.182      | 0.252   |
| PRI     | 99.90 | 7.21 | 102.04 | 5.84 | -2.136      | 0.243   |
| WMI     | 83.54 | 5.52 | 95.50  | 4.31 | -12.955     | 0.049 * |
| PSI     | 90.86 | 6.44 | 97.81  | 5.25 | -6.955      | 0.039 * |
| IQ      | 89.04 | 6.49 | 99.63  | 6.74 | -10.591     | 0.041 * |

\* Statistical significance  $p < 0.001$ .

The comparison between Group 1 and Group 3 showed differences in the following factors: WMI [ $-15.68$ ,  $p < 0.001$ ], PSI [ $-8.86$ ,  $p < 0.001$ ] and IQ [ $-14.68$ ,  $p < 0.001$ ], demonstrating that prolonged exposure to a learning environment by using activities in a second language is related to a greater development of executive functions, to a greater extent in the Advanced group (Gr3) (Table 3).

**Table 3.** Post hoc comparisons between Groups 1 and 3.

| Factors | G1    |      | G3     |      | Differences | p       |
|---------|-------|------|--------|------|-------------|---------|
|         | Means | SD   | Means  | SD   |             |         |
| VCI     | 98.36 | 5.00 | 102.36 | 6.69 | -4.000      | 0.093   |
| PRI     | 99.90 | 7.21 | 103.09 | 4.71 | -3.182      | 0.084   |
| WMI     | 83.54 | 5.52 | 98.22  | 5.04 | -15.682     | 0.012 * |
| PSI     | 90.86 | 6.44 | 99.72  | 5.39 | -8.864      | 0.031 * |
| IQ      | 89.04 | 6.49 | 103.72 | 8.49 | -14.682     | 0.024 * |

\* Statistical significance  $p < 0.001$ .

The comparison between Group 2 and Group 3 did not reveal any significant differences, showing that both groups, following longer exposure than Group 1, provide the same level of development as the executive functions, but are more significant than those exposed to a lesser extent (Gr1). These differences also have a significant impact on global cognitive functioning (IQ) (Table 4).

**Table 4.** Post Hoc Comparisons between Groups 2 and 3.

|     | G2     |      | G3     |      | Differences | p     |
|-----|--------|------|--------|------|-------------|-------|
|     | Means  | SD   | Means  | SD   |             |       |
| VCI | 101.54 | 6.20 | 102.36 | 6.69 | −0.818      | 1.000 |
| PRI | 102.04 | 5.84 | 103.09 | 4.71 | −1.045      | 0.566 |
| WMI | 95.50  | 4.31 | 98.22  | 5.04 | −2.727      | 0.223 |
| PSI | 97.81  | 5.25 | 99.72  | 5.39 | −1.909      | 0.273 |
| IQ  | 99.63  | 6.74 | 103.72 | 8.49 | −4.091      | 0.203 |

#### 4. Discussion

The aim of this study is to investigate whether executive functions are correlated to foreign language learning, specifically English language. Several studies suggest the involvement of EFs in language skills. Language skills in terms of verbal production and comprehension could be described as a process that follows various stages [10,11] where three specific executive functions might play relevant roles. It was investigated if there were any correlations between executive functions assessed by the factors of WPPSI-IV. According to this hypothesis, some authors [9,12] claimed that shifting may involve the ability to monitor the communicative flow of conversation; working memory may involve updating and monitoring information to generate and understand sentences, and to retrieve and organize episodic contents; inhibitory control could be involved in the inhibition of the semantic competitors while producing or understanding words. Various studies suggest that foreign language learning likely promotes executive functions [13]. Accordingly, other authors have suggested that bilingualism has beneficial effects on executive functions. Despite this, there is a current debate on the bilingual advantage hypothesis. This hypothesis suggests that bilinguals perform better in cognitive domains involved in EF [21]. Indeed, a recent large-scale meta-analysis of 152 studies could not find any support for a bilingual advantage across all domains of EF [22,23]. Furthermore, a neurofunctional study [21] in which a non-linguistic cognitive training was conducted, specifically of EF, suggested that the inhibitory control training increased the neural efficiency for language production in terms of attention shifting and conflict resolution between verbal material (words, sentences, etc.). Cascia and Barr [24] determined that both receptive and expressive vocabulary were associated with parent and teacher assessments of executive functions. Joseph and colleagues [25] examined the relationship between executive functions and language skills. Haebig et al. [26] discovered that working memory, shifting and updating, for lexical processing task predicted reaction time and accuracy.

Our results show a relationship between executive functions and foreign language learning emerged from the comparison between the groups and the subtest of WPPSI-IV. In addition, the Intermediate Group (G2) shows a greater effect than the Elementary Group (G1), suggesting that prolonged exposure to a learning environment with the use of activities in a second language is related to a greater development of executive functions (Table 2). In addition, a greater effect is found in the Advanced Group (G3), suggesting that prolonged exposure to a learning environment using activities in a second language is related to a greater development of executive functions. It suggests that the higher the level of foreign language proficiency, the higher the performance of the executive tasks. Finally, we found a significant difference between the scores associated with executive functions tasks and foreign language learning, and we could assume how these processes interact.

We found an actual relationship, but we cannot affirm whether there could be a causal effect between them. The explanation of these results, compared with the contradictory outcomes of previous studies, could be explained by the fact that the bilingual advantage might only occur under certain circumstances, which are not yet fully understood.

## 5. Conclusions

In conclusion, the very few studies that have addressed this topic yielded highly contradictory results. Our results suggest that the relationship between EF and foreign language learning could be found, but we do not know if there is a causal effect. The main weakness of this study is the lack of follow-up to allow us to understand how second language proficiency interacts with the achievement of cognitive tasks (more specifically, the executive ones). In addition, neurophysiological measurements could help unravel the neural correlations of differences based on the degree of competence as other authors suggest [27,28]. Moreover, it could be explored the learning of a more complex language such as French. Finally, we suggest a deeper exploration of these variables.

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