

Research Paper

Comparing the Dimensions of Executive Functions in Monolingual and Bilingual Children

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**Article info:****Received:** 08 Feb 2022**Accepted:** 23 Jul 2022**Available Online:** 01 Jul 2022**Keywords:**Executive functions,
Bilingualism, Monolingualism**ABSTRACT**

Objective: This study aimed to compare the executive functions of bilingual and monolingual children.

Methods: We recruited 200 children, all under 5 years old, who participated in a cross-sectional study. These participants were separated into two groups based on their enrollment in a second language program. Group one consisted of children enrolled in a second language program (Mean±SD age: 9.86±2.69). Group two consisted of children who did not enroll in any second language program (Mean±SD age: 9.63±3.21). Participants' executive functioning was assessed using the behavior rating inventory of executive function. The demographics and the socioeconomic status of all participants have been collected via parental reports.

Results: Bilingual children scored higher in the components of inhibition, shift of attention, emotional control, initiation, working memory, strategic planning, organization of materials, and monitoring. Also, their total score was higher compared to monolingual children.

Conclusion: Early exposure to a second language program during childhood enhances executive functions.

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Highlights

- Bilingual and monolingual children differ in terms of executive function.
- Bilingual children performed better than monolingual children in inhibit, shift of attention, emotional control, initiate, working memory, strategic planning, organization of materials and monitor.
- Early exposure to a second language during childhood development have an enhancing effect on executive function.

Plain Language Summary

Executive functions (EFs) serve as an umbrella term to encompass the set of higher-order cognitive abilities that are necessary to pursue and achieve a goal. Various studies show that bilingualism has many beneficial cognitive effects on executive function. In this regard, the results of this study showed that early exposure to a second language program during childhood development may have an enhancing effect on executive function.

1. Introduction

The interest in comprehending the distinctions among executive functions has been increasing gradually. Executive function is a generalized term that includes distinct but closely related components, when considered together, form a common pattern of functionality (Friedman, Mike, 2017). The literature has considered the core components of executive functions as working memory, cognitive inhibition and flexibility, attentional shift, emotional control, initiation, strategic planning, organization of materials, and monitoring (Devine, Ribner, Hughes, 2019). These multidimensional cognitive structures are essential for purposeful behavior and problem-solving in all dimensions of life, whether academic, professional, or social (Fogel, et al., 2020).

Because a close relationship exists between the development of executive functions and the prefrontal cortex, it has long been believed that executive functions develop during adolescence (Bernier, Carlson, & Whipple, 2010). However, with the growth of Cognitive Neuroscience, it has gradually become clear that the development of executive functions begins much earlier, well before primary school and even as early as 3 years of age (Fiske, Holmboe, 2019). There is even evidence that executive functional development may start to form from infancy (Diamond, 2013) up to adolescence (Carlson, Zelazo, Faja, 2013).

Also, the environment influences childhood development at different periods. Environmental factors may have a greater impact on the development of executive

functions during early childhood (Müller, Baker, Yeung, 2013). Regarding the role and impact of executive functions on people's behavioral inhibition and personal growth, it is important to understand the factors influencing the development of executive functions (Halse, 2014). The general consensus suggested that executive functions developed in interacting with the environment (Bernier et al., 2010). Recently scientific and impartial research has shown that environmental conditions have a significant impact on the development of executive functions (Blair, Raver, 2012). Studies have also shown that factors such as parenting (Sosic-Vasic, et al., 2017), socioeconomic status (Last, et al., 2018), motor development (Abdolmohammadi, et al., 2020) and preterm birth (Abdolmohammadi, et al., 2019) affect the development of executive functions.

Of the many environmental factors that influence the development of the executive function, bilingualism is of particular interest to researchers (Antón, Carreiras, Duñabeitia, 2019). Bilingualism, or multilingualism, is the ability to use two or more languages to communicate with others alternatively (depending on specific situations). This social lingual phenomenon is caused by social behaviors that affect how a person speaks (Ortega, 2019). Bilingualism is a phenomenon that exists in all countries and engages about half of the world's population (Delphi, Delphi, Zarif i an, Bakhshi, 2018). Various studies show that bilingualism has many beneficial cognitive effects on executive functions (Anton et al., 2019), metacognitive awareness (Antoniu, 2019), divergent thinking (Lee, Kim, 2011), phonetic perception (Antoniu et al., 2015), control of cognitive attention, and flexibility (Adi-Japha, Berberich, Libnawi, 2010).

The results of the previous studies on the relationship between executive functions and bilingualism have been inconsistent. For example, [Bialystok \(2017\)](#) and [Kubota, Chevalier, and Sorace \(2020\)](#) found that bilingual children show better performance with respect to executive functions, while [Arizmendi, et al., \(2018\)](#) [Nichols, et al., \(2020\)](#) found no difference in terms of executive functions among bilinguals and monolinguals. This discrepancy between results suggests that the relationship between bilingualism and the development of executive functions requires further research ([DeLuca, et al., 2020](#)).

Objections to the methodologies used within the literature have been raised. For instance, parental literacy and economic status are (often or always?) not controlled within these studies ([Daller, Ongun, 2018](#)). Another concern is that the use of small sample sizes makes generalizing the results difficult ([Paap, Johnson, Sawi, 2015](#)). Additionally, the tools that are often used within these studies can have low validity and reliability and do not always measure people's real-life executive functions accurately ([Abdolmohamadi, et al., 2018](#)).

Consequently, researchers have shown a positive effect of bilingualism in many studies. Although some people speak a language other than Persian in Iran, little research has been done in this field, and many questions about bilingualism remain unanswered. The present study is important because it draws more attention to proper language teaching. Because bilingualism affects executive functions, the responsibilities of parents and the educational system in terms of language learning are doubled. Therefore, the results of this study have a theoretical value in providing useful information about the level of executive functions in monolingual and bilingual people for the country's educational system. Practically, it can draw the attention of education officials to the importance, the role of these processes, and the use of appropriate methods in learning. According to the well-documented relationship between executive functions and bilingualism, this study aimed to compare the executive functions between bilingual and monolingual children despite the inconsistency of reported results and potential methodological shortcomings found in the literature.

2. Participants and Methods

This study used a causal-comparative design. Participants were selected by using available sampling. In this study, bilingual children are those who can speak two languages completely. At first, the mothers

of bilingual and monolingual children were invited to the school, and after explaining the objectives of the test, they were asked to complete the research questionnaire if they were satisfied. To observe the ethical of research subject rights, the researcher first introduced himself to the students and stated the aim of the research, then both orally (before the performance) and written (mentioned in the first part of the questionnaire) ensured that "The information requested in these questionnaires is for research purposes only. To reassure you, apart from determining your gender and age, you do not need to mention your first and last name and other personal details".

Research participants

The official language of Iranian society is Persian. However, there are also several unofficial languages with native speakers; they are required to learn the official language as early as less than 5 years old. Therefore, Iranian society is ideal for investigating the cognitive differences between monolingual and bilingual children. Because the test is causal-comparative, [Cohen's table \(2013\)](#) was used to select the sample size. Although 80 people were enough for each group, according to Cohen's table, 100 people were selected for each group. A group of 100 children who have Azeri-speaking parents and live in Azeri-speaking areas first mastered the Azeri language and then, being exposed to the Persian language in formal education from the age of 5 was compared with a group of 100 children whose mother tongue was Persian and in harmony with the official and educational language of the country. Both groups were selected from public school students. The education level of mothers of bilingual children comprised diploma 35%, postgraduate 8%, bachelor 48%, master 7%, and doctorate 2%, and of the monolingual children as diploma 38%, postgraduate 5%, bachelor 47%, master 9%, and doctorate 1%. The Mean \pm SD age of mothers in the bilingual and monolingual groups were 29.78 \pm 3.24 and 33.83 \pm 2.64 years, respectively. Mothers completed questionnaires due to their more accurate knowledge of children's characteristics. The inclusion criteria were being bilingual in the bilingual group, being monolingual in the monolingual group, bilingual mothers of bilingual groups, children over 6 and under 12, not being diagnosed with severe mental health problems based on students' health records, and parents' literacy level (at least diploma). The exclusion criteria were parents' dissatisfaction and lack of cooperation. Participants' demographic information is reported in [Table 1](#).

Study measures

Behavior Rating Inventory of Executive Function (BRIEF)

The questionnaire, developed by Gioia, Isquith, Guy, and Kenworthy (2000), has the parents and teachers' booklet and assessed performance deficiencies in eight areas: inhibition, attentional shift, emotional control, initiation, working memory, strategic planning, organization of materials, and monitoring. This questionnaire is a tool with high reliability and validity in measuring executive functions, and it has greater value than similar executive function questionnaires due to its assessment of people's real-life behavior. This questionnaire is scored on a modified 3-point Likert scale (never=0, sometimes=1, and often=2) (Memisevic & Sinanovic, 2013).

The questionnaire responses are subdivided into two categorical indicators: Behavioral Regulation Index (BRI) (consisting of inhibition, attentional shift, and emotional control) and Cognitive Index (CI) (consisting of initiation, working memory, strategic planning, organization of materials, and monitoring). Finally, a score of 8 on the scale and the two indices are used to obtain the total score for the BRIEF test (Memisevic, 2015).

The mean Cronbach alpha was between 0.82 and 0.98, and the correlation coefficient obtained after re-testing 3 weeks from the initial assessment for parent's

scales was between 0.72 and 0.84. This retesting result supports this questionnaire's superior validity and reliability compared to previous executive function questionnaires (Gioia et al., 2000). This questionnaire was standardized by Abdolmohammadi et al. (2019) in Iran, with the results showing that the Cronbach alpha, calculated for BRIEF questionnaire scales, is between 0.68 and 0.86. These results indicate that the internal consistency of the questionnaire's scales falls within the appropriate range. The present questionnaire used in this study obtains two indices and a total score in addition to separately measured scales of executive functions. For this questionnaire, the Cronbach alpha calculated for the BRI, the CI, and the total score of the BRIEF questionnaire were 0.86, 0.89, and 0.93, respectively, indicating good internal consistency.

3. Results

First, descriptive statistics of the research variables are presented in Table 1. Wilkes' Lambda test was used to assess the differences between the two groups in Table 2, and Multivariate Analysis of Variance (MANOVA) was applied to compare the components of executive functions between the two groups participating in Table 3.

Table 1 shows that the monolingual group scored higher than the bilingual children in total score and all executive function components though there was

Table 1. Descriptive statistics (n=100)

Variables	Mean±SD	
	Monolingual	Bilingual
Age (y)	9.86±2.69	9.63±3.21
SES	14.53±3.78	13.91±3.47
Inhibition	9.52±5.84	5.38±3.72
Shift	8.01±3.69	4.04±2.60
Emotional Control	8.56±4.11	6.06±3.47
Initiation	6.01±3.35	3.44±2.49
Working Memory	5.99±3.63	3.75±2.79
Plan/Organize	9.59±5.64	5.92±4.84
Organization of Materials	4.66±3.32	2.15±2.29
Monitoring	6.62±3.42	4.39±3.15
Total Score	26.11±12.11	15.50±8.89

SES: Socioeconomic Status

Table 2. The Wilkes' Lambda test results to assess the differences between the two groups participating in the study

Multivariate Tests	Values	F	Hypothesis df	Error df	Sig.
Pillai's trace	0.33	10.17	8.000	165.000	0.0001
Wilks' lambda	0.67	10.17	8.000	165.000	0.0001
Hotelling's trace	0.49	10.17	8.000	165.000	0.0001
Roy's largest root	0.49	10.17	8.000	165.000	0.0001

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a slight difference in socioeconomic status between bilingual and monolingual children on test. It showed that this difference was not statistically significant ($t=1.38, df=198, P<0.16$).

Multivariate analysis of variance was used to compare differences in executive functions between subject groups (monolingual and bilingual). We used Wilks' Lambda to determine F in MANOVA. Pillai's trace, Wilks' lambda, Hotelling's trace, and Roy's largest root were used to investigate the significant difference between the groups participating in the study.

In Table 2, the Wilkes' lambda results ($P<0.0001, F_{8,105}=10.17$) show that the hypothesis regarding the similarity of society's means based on dependent variables for the two groups is rejected. Then the results of the intergroup variance analysis test were used to determine which of the variables was significantly different between the two groups.

As Table 3 shows, higher scores were achieved for all executive function components and total scores of mono-

lingual children compared to bilingual children ($P<0.001$). These results strongly imply that bilingual children showed better executive functional performance across all factors when compared to monolingual children.

4. Discussion

This study aimed to compare the executive functions of bilingual and monolingual children. The results showed that bilingual children performed better than monolingual children in all components of executive functions, and they achieved a higher total score. These findings are consistent with the findings of multiple studies, including [Salvatira, Rosselli, 2011](#); [Woumans, Duyck, 2015](#); [Krizman, Skoe, Kraus, 2016](#); [Chung-Fat, Sorge and Bialystok, 2017](#); [Crespo, et al., 2019](#); [Kubota et al., 2020](#). However, there are still a few studies that show conflicting results ([Arizmandi et al., 2018](#); [Nichols et al., 2020](#)). The findings of this study further support Astana's theory claiming that bilingualism is a significant factor in superior cognitive performance ([Baker, 2006](#)).

Table 3. Multivariate analysis of variance to compare the components of executive functions between the two groups

Dependent Variable	Sum of Squares	df	Mean of Squares	F	Sig.
Inhibition	725.30	1	725.30	32.57	0.001
Shift	663.50	1	663.50	67.69	0.001
Emotional control	263.96	1	263.96	18.74	0.001
Initiation	279.36	1	279.36	33.64	0.001
Working memory	202.34	1	202.34	20.15	0.001
Plan/Organize	570.23	1	570.23	21.15	0.001
Organization of materials	265.86	1	265.86	34.76	0.001
Monitoring	210.42	1	210.42	19.70	0.001
Total Score	4752.31	1	4752.31	44.39	0.001

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In Iran, students are required to use a second language academically while primarily using their mother tongues outside school, either based on interest or social pressure leading bilingual children to develop fluency in both languages. This mastery of both languages resulted in increased cognitive development in bilingual children. Furthermore, research has shown that extra exposure to two languages during childhood positively impacts executive functional development (Crespo et al., 2019). One study supporting this claim conducted on Serbian students showed that children who were exposed to a second language for 5 hours a day showed better executive functions than children who were exposed to a second language for one and a half hours (Purić, Vuksanović, Chondrogianni, 2017). In Iran, because of school attendance and mass media, bilingual children are exposed to a second language for more than 5 hours a day. Based on this fact, the results of this study should not be surprising.

Participants in the present study all started to learn a second language before age five. Previous research has shown that bilingual people who learn a second language before the age of 9 have better performance of executive functions. However, children who learn a second language after the age of nine show functional performance closer to that of monolingual children (Salvatira & Rosselli, 2011).

Various factors could underlie the superior performance of bilingual children in terms of executive functions. Among bilingual children, an important factor is the cognitive use of both languages, which is constantly active during language processing, leading to more consistent language monitoring among bilingual children (Kubota et al., 2020). Additional research also shows that bilingual individuals must continually attend to one language over the other while actively inhibiting usage of the unattended language (Woumans & Duyck, 2015). The situational circumstance must be considered when choosing which language to be used. This selective attention is another important factor considering bilingualism which affects executive functions (Chung-Fat et al., 2017). There is also a high displacement between the two languages, both in terms of vocabulary and grammatical structure (Bialystok, 2017). Some researchers have suggested that displacement between the two languages leads to greater cognitive flexibility among bilingual speakers (Rosselli, et al., 2015). Executive functions manage all of the bilingual factors mentioned here; it is this higher reliance on executive functions during language processing that likely results in the overall strengthening of executive function performance.

Neurological studies also support this by showing greater cortical thickness of the prefrontal cortex in bilingual speakers than in monolingual speakers. According to the role of the prefrontal cortex in executive processing, the increase in gray matter volume provides some neurological explanation regarding the relationship between executive functions and bilingualism (Olulade, et al., 2016).

5. Conclusion

The results showed that bilingual and monolingual children differ in terms of executive functions. Bilingual children showed better performance on the skills related to executive functions compared to monolingual children. Considering the superiority of bilingual children in executive functions over monolingual children, it is necessary to plan early teaching of a second language in preschool education, and appropriate interventions should be designed and implemented according to the developmental characteristics of this age group.

The present study also has some limitations. First, it is the cross-sectional nature of the research method. Longitudinal research is vital because previous longitudinal studies have had different results than cross-sectional studies. Second, the sample group generalizes the results of the present study only to the 6 to 12 years old children. Further research needs to use other age groups and different samples. The third limitation is the collection of information from parents. It is better to use methods for collecting information from students in future research. The fourth is using questionnaires; using other tools in future research is recommended.

Ethical Considerations

Compliance with ethical guidelines

The present study was a comparative causal type study approved by the Regional Committee of Medical Ethics of Tabriz University of Medical Sciences (Code: IR.TBZMED.REC.1398.311).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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