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Research Paper: Comparing Executive Functions in Bilinguals and Monolinguals Suffering From Relapsing-Remitting Multiple Sclerosis

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ABSTRACT

Introduction: Executive functions generally refer to cognitive functions involved in the control and regulation of goal-directed behavior also the formation of mental representations. Several factors such as age, task complexity, and bilingualism affect executive functions. There are opposing effects for the role of bilingualism on executive functions. This study aimed to compare executive functions of bilingual patients with Relapsing-Remitting Multiple Sclerosis (RRMS) with their monolingual counterparts.

Materials and Methods: In this cross-sectional study, 13 bilingual patients with RRMS are compared with 13 monolingual peers. The research instrument included progressive matrices raven test, Mini-Mental State Examination (MMSE) and clinical tests of executive functions (continuous performance test, Wechsler memory test and verbal fluency test). The Mann-Whitney test was used as statistical analysis.

Results: The results indicated statistically significant differences between two groups with regard to correct response, error of omission, and commission error. However, there was no difference in the digit span test. Monolinguals in Persian language, however, performed better than bilinguals in all verbal fluency tasks.

Conclusion: Bilingualism promotes cognitive ability and executive functions in nonverbal tasks. Ironically, it seems that the only recorded negative impact of bilingualism are on verbal knowledge and skill.

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1. Introduction

Multiple Sclerosis (MS) is an autoimmune and progressive central nervous system disease [1, 2]. It is often seen in young women; its prevalence in women is four times than men [1]. MS prevalence is between 2 to 150 individuals per 100000 depending on the country and population. The statistics show that in Iran 35000 to 40000 individuals suffer from MS where it is considered as the second reason of young people disability [3].

According to the disease progress, there are four clinical types of MS: Relapsing-Remitting Multiple Sclerosis (RRMS), secondary progressive MS, progressive relapsing MS, and initial progressive MS. The most common form is RRMS, having the gravest symptoms in attacks and then relative improvement. MS is associated with a wide range of direct and indirect symptoms [4]. Cognitive problems is one of the most important signs in these patients studied especially in recent studies. Cognitive disorders among MS patients are reported as difficulties in attention, information processing, executive functions, process speed, and dysfunctional long-term memory [3].

According to the studies conducted in 1980s and afterwards, the prevalence of cognitive impairment in MS patients is reported to be 44% to 70% [5]. Executive functions are among the cognitive aspects that researchers paid special attention to in MS patients in recent years. These are a set of high level cognitive skills controlling and adjusting lower level cognitive processes and targeted behaviors [6], guiding other mental capacities such as reasoning and language [7]. Executive functions have an important role in emotional and behavioral control, cognitive function, and social interaction [8]. These functions include concepts such as permanent and selective attention, working memory, and inhibition [6], each playing a significant role in cognitive control. The roles include filtering non-significant information and paying attention to important aspects of assignments, applying them in the future, and preventing inappropriate responses [9].

Executive action disorder results in problems such as lack of concentration and attention, acting without thinking, weak working memory, problem in organizing activities, disability in planning in advance, disorder in action, weak reasoning, problem in producing or running various methods, resisting behavior change when required, and lack of learning from mistakes [10]. Different factors affect executive functions such as bilingualism, task complexity, and age [11].

Bilingualism is one of the key factors on executive functions. In this regard, studies have shown that the regular use of two languages in a bilingual scan affects executive and cognitive functions of the patients [12, 13]. Comparing executive functions of monolingual and bilingual children demonstrates faster growth of functions in bilinguals compared to monolingual ones [14]. These functions are preserved better in bilingual adults than in their monolingual peers [15]. Moreover, studies reveal that older bilinguals had better executive functions than younger ones and bilinguals act better in complicated non-verbal assignments [11].

Meltzoff and Carlson (2008) report that bilingual children have better functions in executive control assignments which require attention inhibition for selecting a conflicting response [16]. In addition, research on adults indicates that in conflicting conditions, the bilinguals response faster than monolinguals [17, 18]. Various studies reported the superiority of bilinguals' proficiency over monolingual ones [19-21].

Studies show that 15% to 20% of MS patients suffer from deficiency in executive functions such as working memory, semantic and phonological fluency, attending assignments with high level of cognition and planning [22, 23]. Moreover, ability in permanent attention, reasoning and self-control, perceiving high level language skills and their function are lower in these patients [24]. On the other hand, these cognitive-lingual impairments can have significant impact on recruitment, social functions, work activities, patient's general functions, and their life quality. However, neurologists and speech and language pathologists generally do not evaluate and diagnose these impairments precisely, and therefore these patients do not receive efficient treatment.

On the other hand, patients generally are not aware that speech and language pathologist might help them improve these skills with rehabilitation exercises [4]. For this reason, studying cognitive-lingual skills in MS patients and factors affecting them can result in increasing specialists' awareness, performing more accurate diagnostic evaluations, and providing more general treatments for these patients. Therefore, the present study aimed at discussing executive functions in relapsing-remitting bilingual MS patients and comparing them with their monolingual peers.

2. Materials and Methods

Twenty-six adults with Relapsing-Remitting MS (RRMS) participated in this comparative-analytical

study. To select the samples, we used non-random and convenience sampling method. Participants were divided into two groups of 13 patients each. The first group included 13 bilingual adults with RRMS, and the second group included 13 monolingual adults with the same type of MS.

Both groups were matched in terms of age, sex, education, and socio-economic condition. The inclusion criteria were as follows: age 20-40 years, grade 5 or less in disability (Expanded Disability Status Scale [EDSS]), no history in neurological or psychological disease or abuse of alcohol or drugs, absence of depression based on Beck Depression Test (checking the case in MS Association), no extreme physical injuries (movement, eyesight, vocal), no cognitive problem based on MMSE test, with minimum reading and writing skills, normal intelligence, Persian speaker for being monolingual and Arabic-Persian speakers for bilingual examinees based on self-report, no relapse of the disease in the recent two months, and not under steroid medications in the last two months (based on the MS Association report). Raven progressive matrix test was carried out for IQ screening, and bilingualism was defined based on self-report.

Bilingual individuals were asked to rate themselves 1-5 based on their proficiency in the second language. An examinee with the grade of 3 or more could attend the study [25]. In addition, a short Mini-Mental State Examination (MMSE) was administered to exclude patients with cognitive disorders [26]. The inclusion and exclusion criteria, and the tests related to executive functions were performed individually at two separate sessions in a quiet room. In the first session, the participants were studied based on inclusion and exclusion criteria and if the inclusion criteria were met, they would complete the consent form to participate.

In the second session, the selective tests were administered to evaluate executive actions. All tests were performed by a speech and language pathologist under the supervision of a psychologist. In the present study, working memory was evaluated using the Wechsler Cultivar test (direct-reverse). Direct cultivar subscales were used to test short-term memory and attention. Reverse cultivar subscales are important tools for evaluating working memory because not only the test needs attention and coding, but also each examinee should keep the information in mind for a short time, process, and then present them.

Using retesting method, the alpha Cronbach coefficient was obtained as 65% and reliability coefficient as 83% [27]. The computer version of cultivar test was applied, including audio section to test verbal working memory and visual section to test non-verbal working memory. The test stopped automatically when the examinee was not successful in a sequential effort related to certain numbers. Given that there were 7 groups of numbers in this test, the maximum score for each audio and visual section was 14.

Continuous performance test was used to evaluate attention and inhibition. This study aimed at testing accuracy and permanent attention [28]. After displaying some letters or numbers swiftly, the examiners asked the patients to look at the screen in one of the most common versions of this test. The examinee had to answer when monitoring a certain stimulus or a pair of certain sequential stimulus. The scores were as follows: the number of correct answers, reaction time, the number of not answering the target stimulus (elimination error), the number of answers to the minor stimulus (answering error). Answering error measures both permanent attention and shock control, while elimination error and the number of correct answers both measure permanent attentions [29].

Verbal fluency test was used to evaluate executive functions. This test was appropriate to study acquired language disorders due to different reasons, including two subtests: semantic fluency and phonological fluency. Ebrahimipour and Mardani (2012) examined the reliability and validity of the test. Moreover, content validity, inter-examiner reliability, correctors' reliability, and test repeatability were confirmed. To study verbal and semantic fluency, two subtests of animal names and fruit names were used. The examinee was asked to name some animals and fruits in two separate time spans of 60 seconds. Before the test, the examinee was instructed to articulate each word just once and not to repeat any word.

After instructing the examinees in advance not to use proper nouns, the same words, or different grammatical suffixes, in phonological fluency section, we asked the examinees to state words starting with /a/, /f/, and /s/ in three separate time spans of 60 seconds [30]. In the present work, we asked the examinees to do the assignment of verbal fluency twice (once in Arabic, once in Persian). All the examinees' answers were recorded in both languages, then analyzed by a specialist in speech and language pathologist.

In the analysis section, the Kolmogorov-Smirnov test was used to examine data normality, and the Whitney test was used to compare semantic fluency, phonological fluency, memory, attention, and inhibition in bilinguals

and monolinguals. The obtained data were analyzed using in SPSS 22 at significance level of P<0.05.

3. Results

This study was performed on 26 relapsing-remitting bilingual and monolingual MS patients with the age range of 20 to 40 years. The patients included 14 women and 12 men. Fourteen patients had diploma, 10 had bachelor', and two had master's degree.

The findings of the Whitney test on comparing the examinees' performance mean in both groups for different components of the cultivar test (audio-direct, audio-reverse, visual-direct, visual-reverse) and continuous performance test (correct answer, elimination error, answering error, and reaction time) showed a significant difference between two groups' performance in terms of all continuous performance test components except the reaction time. Therefore, bilingual group had better grades and performance than monolingual group in all components except reaction time (in reaction time bilingual yielded better performance, but it was not significant). There was no significant difference between audio and visual figures in the performance of both groups in cultivar test. Meanwhile, bilingual group had a better performance in both components of visual cultivar test (Table 1).

Comparing speech fluency, semantic and phonological fluency mean of Persian in bilingual and monolingual RRMS patients showed that the number of fruits and animals, general semantic fluency, phonological fluency of letters /s/, /f/, and /a/, and the general speech and phonological fluency means were significantly higher in monolinguals than in bilinguals. Thus, monolinguals had a better performance in all mentioned tasks compared to their bilingual peers (Table 2).

4. Discussion

Several research studies have examined executive functions in various disorders, the impact of bilingualism on executive functions, and compared bilinguals and monolinguals in different fields of executive functions. In this regard, our results on studying and comparing executive functions in bilingual and monolingual RRMS patients support significant difference between permanent attention and inhibition in the two groups and bilingual RRMS patients had better performance in continuous performance test compared to their monolingual peers. Moreover, significant difference was found in answering error, elimination error, and correct answers between two study groups.

The present study indicates bilinguals' proficiency on monolinguals in permanent attention and inhibition. These findings were in line with Mann and Foy (2014) findings. They mentioned that bilinguals were better than monolinguals in non-verbal assignments [31]. Thus, it seems that bilingualism is a factor affecting attention and inhibition. Regarding that MS patients have difficulties in attention and inhibition, we can consider bilingualism as an effective factor in increasing attention and inhibition in patients.

Table 1. Examinees' performance Mean±SD in different components of the cultivar testing and continuous performance test

Test Components	Group	Monolingual		Bilingual		P
	Variable	Mean	SD	Mean	SD	
Audio cultivar test	Direct figures	5.08	1.70	5.31	1.75	>0.999
	Reverse figures	5.77	1.96	5.23	1.87	0.762
Visual cultivar test	Direct figures	6.30	1.54	6.53	1.19	0.545
	Reverse figures	5.92	1.75	6.30	1.54	0.479
Continuous performance test	Correct answer	147.38	1.98	149.46	0.96	0.003
	Elimination error	1.31	1.70	0.15	0.37	0.026
	Answering error	1.31	0.751	0.38	0.76	0.009
	Reaction time	498.15	63.60	459.77	25.48	0.064

Table 2. Mean±SD of the examinees' performance for different components in speech fluency test for each group separately

Group / Variable	Monolingual		Bilingual		P
	Mean	SD	Mean	SD	
The number of fruits	17.31	2.65	14.08	2.29	0.003
The number of animals	20.62	4.78	15.62	4.64	0.029
Semantic fluency (fruits-animals)	37.23	7.98	30	6.74	0.029
The number of /a/	9.31	2.46	6	3	0.003
The number of /f/	8.31	3.88	5.08	2.72	0.004
The number of /s/	9.85	4.12	6.08	2.43	0.005
Phonological fluency (a, f, s)	27.46	9.28	17.15	7.3	0.001
Speech fluency (semantic and phonological fluency)	32.34	8.27	23.65	6.22	0.006

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Other study findings indicate no significant difference between the two groups in audio and visual cultivar test. These findings were consistent with the results of Namazi (2010), Pascale et al. (2011), Bialystok et al. (2008), and Bialystok et al. (2009) studies. Their studies on bilinguals and monolinguals do not support any significant difference in working memory [11-13, 32]. However, other studies report that working memory is better in bilinguals than monolinguals [14]. Generally, these differences may be the result of individual differences such as intelligence, language type, different assignments and tests, and proficiency in language [7].

The results on verbal, semantic, and phonological fluency between bilingual and monolingual RRMS patients reveal that bilinguals have weaker performance in all phonological and semantic fluency sections. These findings are in line with the findings of Tiffany et al. (2010). In their research, they found that bilinguals had less correct answers and slower recovery than monolinguals in verbal fluency assignments [33]. These findings are consistent with the semantic results of Gollan et al. (2002), Rosslli et al. (2000), and Portoccarrero et al. studies, indicating monolinguals' proficiency in semantic fluency, and similar performance of both groups in phonological fluency [34, 35]. However, some studies have conflicting results. Some emphasize on similarities between monolinguals and bilinguals in verbal fluency assignments [11, 25].

Generally, studies on comparing verbal fluency in monolinguals and bilinguals yield different results which can be related to the type of bilingualism, the age of acquiring language, the way of learning two languages, and the education degree [36]. Bilingualism plays an important role in cognitive ability and executive functions improvement. The majority of studies support the effect of bilinguals' proficiency on in non-verbal assignments compared to monolinguals' [5, 6, 31].

In the present study, RRMS bilinguals had better performance in attention and inhibition assignments than their monolingual peers. In addition, the bilingual group showed a better performance in both components of visual cultivar testing. However, the difference was not statistically significant that maybe because of the sample size. The only negative consequence resulting from bilingualism is related to verbal knowledge and skill. To explain this finding, we can say that verbal fluency test forces a lot of demands on the speed of information process. Therefore, verbal fluency deficiency may reflect the decrease of information process speed, not the weakness in executive functions [36].

Given that the current study was conducted in Persian for the first time in patients with MS, it was difficult to find a test in which performance was appropriately evaluated. Because of the limited number of patients eligible for the study, there were limitations in the choice of sample size. It is suggested that future studies be conducted with bigger sample size to yield more accurate data. By implementing the same research on other languages (Turkish, Kurdish, Lori), more reliable results will hopefully be achieved on the impact of bilingualism on the performance of individuals. It is also suggested that exec-

utive performance tests be performed on other language disorders (such as aphasia, Parkinson, or Alzheimer).

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article. The participants were informed about the purpose of the research and its implementation stages; They were also assured about the confidentiality of their information; Moreover, They were allowed to leave the study whenever they wish, and if desired, the results of the research would be available to them.

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Authors contributions

All authors contributed in preparing this article.

Conflict of interest

The authors declare no conflict of interest.

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