

Research Article



The Relationship between Cognitive Function, Syntax, and Severity of Dysarthria in Persian-Speaking Patients with Multiple Sclerosis

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ABSTRACT

Introduction: Multiple sclerosis (MS) is a degenerative disease affecting the central nervous system. Patients with MS experience several difficulties in the fields of speech, language, and cognitive abilities. This study aimed to investigate the relationship between cognitive functions, syntax, and the severity of dysarthria in Persian-speaking patients with relapsing-remitting multiple sclerosis (RRMS), as well as comparisons with healthy non-patient individuals.

Materials and Methods: This cross-sectional study compared 31 patients diagnosed with RRMS to 31 healthy adults matched with the patient group based on age, gender, and education level. Participants were assessed using the montreal cognitive assessment (MoCA), as well as the syntax comprehension subtest from the bilingual aphasia test and the sentence production test. Additionally, the presence of dysarthria was evaluated through the Frenchay dysarthria assessment (FDA-2), and the dysarthria's severity was determined using the visual analog scale (VAS) by three Speech and language pathologists based on the recorded speech samples.

Results: The findings revealed a significant difference between MS patients and the control group ($P \leq 0.05$). Additionally, the results showed a significant correlation between dysarthria severity and both syntax comprehension ($P=0.002$, Cohen's $d=0.803$) and syntax production ($P=0.005$, Cohen's $d=0.820$), as well as the MoCA ($P=0.001$, Cohen's $d=0.579$). Furthermore, significant correlations were also found between the MoCA and both syntax comprehension and syntax production within the patient group ($P \leq 0.05$). The data was analyzed by SPSS software, version 26. The difference between the two groups was calculated using the independent t-test, and the correlation between them was analyzed using the Spearman test at a significance level of $P \leq 0.05$.

Conclusion: Syntactic challenges in MS patients might be linked to underlying cognitive impairments, and as the severity of dysarthria increases in patients, their syntactic problems also escalate. The results of this study can help speech and language pathologists in clinical evaluations and in providing comprehensive treatment plans for patients with MS.

Keywords:

Multiple sclerosis; Cognition; Syntax; Dysarthria; Persian language

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Introduction

Multiple sclerosis (MS) is a degenerative disease affecting the central nervous system. MS is characterized by damage to the myelin sheath surrounding nerve cells and the formation of plaques in the white matter of the brain and spinal cord [1]. The prevalence of MS in the world has been reported as 35.9 people per 100,000. At the same time, research has estimated a range of 5.3 to 74.28 individuals per 100,000 in Iran, suggesting a rising trend in the incidence of this condition in the country [2, 3]. The prevalence of this disease in females was four times that of males, and it is currently recognized as the second leading cause of disability among Iranian youth [4]. Four clinical types of MS exist, based on the speed of disease progression and MRI results: Clinically isolated syndrome (CIS), relapsing-remitting MS (RRMS), secondary-progressive MS (SPMS), and primary-progressive MS (PPMS). The most common type of disease is RRMS, which affects 85% to 90% of patients [5, 6]. This type of disease is characterized by unpredictable attacks or relapses followed by either partial or complete recovery. Relapses typically happen in a subacute manner, arising within several hours to a few days. Symptoms then stabilize for several weeks before gradually improving during the recovery phase, which can extend over weeks to months.

Individuals diagnosed with progressive neurological diseases such as MS experience a wide range of challenges, with symptoms that extend beyond sensory and motor dysfunction. Historically, it was believed that the damage caused by this disease primarily affected subcortical brain regions, while cortical regions were considered primarily responsible for language processing. As a result, the interaction between cognitive and linguistic functions in this population remained largely unexplored in earlier research [7]. Approximately 75% of individuals with MS self-reported experiencing language difficulties, including naming [8], high-level pragmatic skills [9, 10], semantic paraphasia [11], and problems in syntax characterized by a reduction in word count, omission of grammatical elements, and shorter mean utterance lengths [12-14]. Furthermore, these individuals exhibit lower linguistic complexity [11] and struggle with comprehending high-level language, such as metaphors and idioms [15]. The prevalence of cognitive impairments in MS patients ranges from 40% to 65% [16, 17]. MS affects various aspects of cognitive performance, leading to difficulties in attention, both short-term and long-term memory, processing speed, information processing, and executive function.

Additionally, these patients experience challenges in visual-spatial and verbal learning, and their ability to recall information is often delayed [1, 18]. Dysarthria, as a speech disorder, has a prevalence of 40% to 55% in MS patients, which statistics indicate that the symptoms of dysarthria in MS patients, including slurred speech, production problems, slow speech rate, and drooling, should be closely monitored [19]. According to King, a significant relationship exists between the severity of dysarthria (assessed through intelligibility) and cognitive-linguistic deficits. Furthermore, if individuals with MS do not exhibit cognitive deficits, their syntax and sentence length remain typical, showing no significant difference compared to non-patients [20]. Likewise, Rahimifar et al. investigated the effect of cognitive impairments through the repetition of long sentences in Persian, revealing a correlation between cognition and syntax; patients without cognitive deficits did not experience any syntactic problems [12].

On the other hand, a relationship has been shown between cognitive problems and the severity of patients' dysarthria [21]. As previously noted, MS impacts both sensory and motor functions, involving cortical and subcortical regions of the brain. Consequently, patients with MS often exhibit varying degrees of impairment in speech and language, cognitive abilities, and motor skills. This condition raises the question of whether a significant association exists between cognitive functioning, language deficits, and the severity of dysarthria in this population.

In general, the findings of the studies suggest a potential for cognitive and language difficulties across different types of MS, without attributing these difficulties to a particular type of the disease [22-24]. Additionally, research indicates that patients with dysarthria tend to perform worse on cognitive and language tests. It is therefore reasonable to hypothesize that a greater severity of dysarthria is associated with a marked decline in cognitive and linguistic test performance [19-22]. Given that language assessments were confined to specific aspects of language, such as naming and cognitive assessments were also restricted to certain tests for these patients [13, 17], it appears crucial to conduct a more thorough and in-depth analysis of language disorders such as syntax, which encompasses comprehension and production, and to explore cognitive abilities and the severity of dysarthria in patients with MS. The present study hypothesizes a relationship between cognitive impairment, syntax, and the severity of dysarthria in patients with MS. Therefore, this study aimed to determine how syntax, cognition, and the severity of dysarthria are

connected in these patients. Additionally, it assessed the performance of patients with MS in syntax comprehension and production, as well as cognitive abilities, comparing these results with those from matched healthy non-patients. With these results, speech and language pathologists will be able to enhance their evaluation and treatment services for these patients, ultimately leading to improved quality of life, reduced treatment costs, and accelerated treatment processes.

Materials and Methods

Study participants

In this cross-sectional study, the researchers investigated whether the syntactic and cognitive skills of patients with RRMS differ from those of healthy individuals, and whether there is a relationship between syntax, cognitive skills, and the severity of dysarthria in these patients. The sample for this research consisted of 31 patients with RRMS from the Iranian MS Association and 31 matched healthy individuals in terms of age, sex, and education. Healthy participants were recruited from public locations such as libraries, sports centers, and other community settings to ensure accessibility and population diversity.

Sampling was conducted after receiving the ethical code from the [Tehran University of Medical Sciences](#). Before the sampling process, the patient or their family members completed the informed consent form.

The subjects of this study met the following inclusion criteria: a) the age range was between 18 to 65 years, b) being monolingual in Persian (in case of bilingualism, they demonstrated full proficiency in the Persian language), c) having at least elementary literacy, d) not having vision and hearing problems or uncorrected hearing and vision, e) were diagnosed with RRMS and not used steroids in the preceding 8 weeks, f) their disease duration was at least 2 years, g) exhibiting dysarthria according to the second version of the Frenchay dysarthria assessment (FDA-2) [25], and h) lacking other neurological and psychological problems as determined by a neurologist and psychiatrist. Once the patients meeting the inclusion criteria were included in the study, the research team conducted the FDA-2 test to identify patients with dysarthria; those without dysarthria and individuals unwilling to participate were removed from the study. The criteria for including healthy non-patient participants were the same, except for the presence of MS. Participation in the study was voluntary, and participants were assured that their information would remain confidential.

Assessment tools

The assessment tools used in this research included the following:

The personal information questionnaire was designed to gather information such as age, gender, educational background, duration of the disorder, comorbidity, and medications. FDA-2 (Persian version) was used to detect the presence of dysarthria in patients with MS. This test consists of various parts to evaluate reflexes, breathing, lips, tongue, larynx, and intelligibility. Each part is assigned a qualitative score, and ultimately, the overall performance is determined to indicate whether the individual has dysarthria. The test demonstrates strong validity and reliability, with content validity at 95% and internal consistency measured at 0.96 ($P \leq 0.05$) [25].

The Persian adaptation of the Montreal cognitive assessment (MoCA-P) is used to determine individuals' cognitive performance. This test measures cognitive performance through various domains, including short-term memory, visual-spatial skills, executive functions, attention, concentration, working memory, language, and time and place orientation. A score below 26 indicates that the individual may have cognitive impairments. The MoCA exhibited good sensitivity in identifying MCI and AD (90% and 100%, respectively) [26].

In the sentence production test, individuals' syntactic skills are examined through their ability to create sentences using 20 reversible transitive Persian verbs across four sentence types (active, passive, topicalized, and focusing). The participant is allotted 10 seconds to produce a sentence according to the provided pictures. A total of 80 sentences are presented, with 1 score given for each correct answer. However, if any word is missing or if the verbs are incorrectly chosen, the answer is considered incorrect and receives a score of 0. For this test, the content validity for verbs ranged from 63.87 to 94, while the content validity of nouns was between 82.33 and 94. Each verb was paired with four types of sentences, and the face validity of the pictures representing these sentences was assessed to be between 85 and 96.67 [27].

The syntax comprehension subtest of the bilingual aphasia test (BAT-Farsi version) is used to determine individuals' performance in syntax comprehension. In this test, the examiner reads a total of 86 sentences, which include active, passive, subject relative clauses, and object relative clauses. The participant must then select and indicate the correct picture that corresponds to each sentence. Each correct answer is awarded 1 point; conversely, if the

participant answers incorrectly or fails to respond within the allotted time, they receive a score of zero. The scoring range for this subtest is from 0 to 86, with higher scores reflecting better comprehension skills [28].

To evaluate the severity of dysarthria, speech samples from patients, which included descriptions of a “bird’s nest” picture and their occupation, were recorded and analyzed by three speech and language pathologists specializing in speech motor disorders. Each evaluator assigned scores based on the intelligibility and speed of conversation, while also considering the frequency and length of pauses, using a visual analog scale (VAS) that ranged from 1 to 10, where a higher score indicated a greater severity of dysarthria. By averaging the scores from three evaluators, the severity of dysarthria was established for each individual.

Finally, the data were analyzed by SPSS software, version 26. In the descriptive statistics, we calculated the mean, standard deviation, and mean difference for cognitive, syntax, and severity of dysarthria. The independent t-test was used to assess the differences between the two patient groups and healthy non-patients, and the correlation between them was evaluated using the Spearman correlation test at a significance level of $P \leq 0.05$.

Results

In this research, 62 individuals participated in two groups: Patients with MS and a group of healthy non-patients, who were homogeneous in terms of age, gender, and education with the patients. Among the participants, 80% of patients and 71% of healthy individuals were female, resulting in a ratio where the number of female patients was four times that of male patients. There was no significant difference between the two groups in terms of age, gender, and educational level ($P > 0.05$). Table 1

compares average scores for syntax comprehension, syntax production, and cognitive abilities as assessed by the MoCA, highlighting a significant difference ($P < 0.05$).

It should be noted that the average duration of disease in the patients was 11.42 ± 7.27 years, while the average severity of dysarthria was recorded at 2.72 ± 1.56 years. In Table 2, the Spearman correlation coefficient is used to explore the relationship between disease duration and dysarthria severity in relation to scores for syntax comprehension, syntax production, and cognitive function.

The results indicate a negative and significant correlation between the severity of dysarthria and both syntax comprehension and syntax production, as well as cognition ($P < 0.05$). In other words, as the severity of dysarthria increases, scores for cognition, syntax comprehension, and production tend to decrease. Table 3 illustrates the relationship between syntax comprehension, syntax production, and cognition in the patients, indicating that this correlation is both significant and strong ($P < 0.05$).

Discussion

The current study was conducted to compare cognitive performance, syntax comprehension, and syntax production in MS patients and healthy non-patients. Additionally, it explored the relationship between cognition, syntax comprehension, and production in MS patients, along with the severity of dysarthria, which is discussed separately below.

The findings showed that although multiple sclerosis (MS) is 4 times more common in women than in men, there is no significant difference between syntax and cognitive function or the severity of dysarthria between the two genders.

Table 1. Comparing mean scores of syntax comprehension, syntax production, and cognition between two groups (n=62)

Test	Participant Group	Mean±SD	95% CI		df	t	P*	Cohen's d
			Lower	Upper				
Syntax comprehension	Patients (n=31)	78.39±9.46	-9.21	-2.009	35.39	-3.16	0.003	0.803
	Non-patients (n=31)	84±2.85						
Syntax production	Patients (n=31)	71.32±10.59	-10.30	-2.33	33.67	-3.22	0.003	0.820
	Non-patients (n=31)	77.65±2.62						
Cognition	Patients (n=31)	25.35±3.62	-3.28	-0.20	60	-2.26	0.027	0.579
	Non-patients (n=31)	27.1±2.27						

Cohen's d interpretation: Small: 0.2-0.49; medium: 0.5-0.79; large: ≥ 0.80 , * $P < 0.05$.

Table 2. The correlation coefficient between the severity of dysarthria and the scores of syntax comprehension, syntax production, and cognition

Variable		Syntax Comprehension	Syntax Production	Cognition	Severity of Dysarthria
Severity of dysarthria	Correlation coefficient	-0.53	-0.48	-0.58	1
	P	0.002*	0.005*	0.001*	-

*P<0.05.

JMR

Table 3. Correlation between syntax comprehension, syntax production, and cognition in patients (n=31)

Variables	Syntax Comprehension		Syntax Production	
	r	P*	r	P
Syntax comprehension	1	-	0.65	0
Syntax production	0.65	0	1	-
Cognition	0.75	0	0.79	0

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This section outlines the objectives of the study, which are addressed in two subsequent parts: first, the comparison of syntactic comprehension and production, as well as cognitive performance, between individuals with MS and healthy controls; and second, the examination of the study's hypothesis concerning the relationship between dysarthria severity and syntactic and cognitive functioning in patients with MS.

Syntax and cognition in MS patients and non-patients

The findings of the present study indicate significant differences in syntax comprehension and production, as well as cognition in Persian-speaking individuals with RRMS, compared to healthy non-patients, with patients scoring lower. This finding is consistent with Rahimifar et al. [12], Jamalpour et al. and Zivadinov et al. [29, 30], all of which have demonstrated that syntactic functions are diminished in patients relative to healthy non-patients. In Jamalpour et al.'s study [29], the patients exhibited no cognitive problems. However, through descriptive tasks and spontaneous conversations, they concluded that a significant difference existed between the mean length of the longest utterances and the total number of sentences between MS patients and healthy individuals, indicating that MS patients experience difficulties in syntax production. Using the repeating long sentences task, Rahimifar et al. [12] found that individuals with MS who do not exhibit cognitive impairment had a greater tendency to omit content words and reduce their overall word count compared to healthy individuals. Similarly, Zivadinov

et al. [30] also evaluated RRMS patients without cognitive deficits using the BAT test. The findings from these studies suggest that even patients without cognitive challenges demonstrate poorer syntactic abilities compared to their healthy counterparts. Šubert et al. [14] examined the reduction of sentence length and the decreased use of grammatical words in both conversations and spontaneous speech as a syntactic characteristic among individuals with MS, aligning with earlier studies. Additionally, Soltani and Rahimifar [13] analyzed tasks such as picture description, sentence repetition, and spontaneous speech, revealing that the syntactic difficulties faced by patients are particularly associated with those who have cognitive impairments.

Although studies involving Persian speakers have employed various tasks and different sample sizes, they consistently reveal that patients with this type of MS experience syntactic difficulties, regardless of the cognitive impairments present in the subjects or the specific tasks used for syntax comprehension and sentence production. In essence, the goal of the aforementioned studies is to compare the syntactic difficulties faced by patients with those of healthy individuals, while controlling for cognitive effects.

In more detail, the findings of the present study indicate that in patients with MS, there is a significant correlation between syntax production and cognitive performance, as well as between syntax comprehension and cognitive abilities. Consequently, individuals who perform better

on cognitive assessments tend to achieve higher scores in both syntax comprehension and production. This finding aligns with the results of Grigoriadis et al. [18] and Sonkaya and Bayazit [31], who reported that patients experiencing cognitive difficulties often exhibit decreased syntactic performance, with this decline worsening as cognitive difficulties intensify.

Additionally, Arronda et al. [15] found a significant correlation between cognitive performance in patients and the length of their sentences, revealing that individuals with cognitive impairments tend to produce shorter sentences and fewer words compared to their peers without cognitive difficulties and healthy non-patient individuals. Therefore, the findings from various studies, regardless of the use of different syntactic and cognitive tests, suggest the presence of issues related to syntactic comprehension and production. Furthermore, these syntactic problems are positively correlated with cognitive difficulty. In other words, as the cognitive impairments of patients increase, they exhibit greater deficits in both syntactic comprehension and production. Additionally, the findings of this study showed that in patients, the correlation between syntax production and cognition was stronger than that between syntax comprehension and cognition.

It is essential to note that this study revealed a significant correlation between syntax comprehension and syntax production in patients with MS.

As a result, higher syntax comprehension was associated with improved syntax production. The research is among the initial studies examining syntax production with a reliable syntax assessment, attempting to explore syntax comprehension and production separately in these patients. Therefore, there was no other research under these specific conditions to establish this connection. Nevertheless, this study successfully validated the presence of deficits in both syntactic comprehension and production among patients with MS.

Dysarthria severity, syntax, and cognition in MS patients

The results also indicated a significant inverse correlation between the severity of dysarthria and syntax comprehension, syntax production, and cognitive functions, suggesting that as dysarthria severity rises, individuals' performance on these assessments declines. Mackenzie and Green [32] examined the severity of dysarthria in patients based on their speech intelligibility. They reported a strong correlation between the severity of

dysarthria and their outcomes on language tests, aligning their findings with those of our study. The findings from the review study conducted by Noffs et al. [33] and Feenaughty et al. [21] support the notion of a connection between dysarthria and cognitive impairments. However, Feenaughty et al. [22] examined the severity of dysarthria through speech intelligibility and found no significant relationship between speech intelligibility and cognitive performance. This discrepancy may arise from various factors, including differences in patient populations, the specific type of MS being studied, and the tests used to assess the severity of dysarthria and speech intelligibility.

Conversely, Mackenzie and Green [32] found a strong correlation in their study of patients with chronic progressive MS between the severity of dysarthria (measured by speech intelligibility) and cognitive test performance, indicating that individuals with low speech intelligibility tend to perform poorly in cognitive tests. Similarly, Smith and Arnett [19] noted, after analyzing 97 patients with MS, that the lower mean scores of patients in some cognitive tests were attributed to a reliance on verbal skills. Still, overall, those with dysarthria scored significantly lower on cognitive tests compared to their counterparts without dysarthria. There was a significant negative correlation between the severity of dysarthria and cognitive test performance. Nonetheless, the decline in cognitive function of patients without dysarthria was also significant compared to that of their healthy non-patients. Overall, the results of our study revealed a negative correlation between dysarthria severity and both cognitive and syntactic abilities, indicating that increased severity of dysarthria was associated with lower performance in cognitive tasks as well as in syntactic comprehension and production. A negative correlation reflects an inverse association between speech motor abilities and linguistic and cognitive functions, whereby increased impairment in motor speech skills corresponds with diminished performance in language and cognitive domains.

The study's limitations included the inability to examine additional demographic characteristics in the patient group, such as motor disorder examination, disease severity-based division (e.g. expanded disability status scale scores), gender balance, and the use of a larger sample size. Additionally, it did not assess patients without dysarthria and did not recruit a homogeneous control group. Therefore, it is suggested that future research examine psychological and social status in addition to physical and movement characteristics, and assess how these factors impact patients' cognitive abilities, speech,

and language (e.g. spontaneous speech and functional language use). Additionally, it is recommended that various tests be used for these assessments to better and more precisely identify higher-level syntactic processing (e.g. ambiguity resolution), other cognitive tests, control the confounder variables such as fatigue, depression/anxiety, medications, and evaluate suitable rehabilitation programs before the disease worsens.

Future Studies

Future research is anticipated to explore additional complex language functions in this patient population, as well as to investigate the associations between cognitive, linguistic, and speech impairments and relevant demographic variables.

Conclusion

In contrast to previous research, the present study examined the integrated relationship between dysarthria severity, cognition, and syntax abilities, yielding novel insights into this domain in the field. The findings indicate that individuals with MS exhibit significant impairments in both cognitive and syntactic domains compared to healthy controls. Specifically, patients with RRMS demonstrated markedly lower performance, highlighting difficulties in cognitive processing, syntactic comprehension, and production. Moreover, cognitive deficits were closely associated with syntactic impairments, and both were exacerbated as dysarthria severity increased. Although cognitive challenges were evident across all levels of dysarthria, greater severity intensified these difficulties. These results underscore the importance of comprehensive assessment by speech and language pathologists, including evaluation of syntactic and cognitive functions in individuals with MS.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of [Tehran University of Medical Sciences](#), Tehran, Iran (Code: IR.TUMS.FNM.REC.1402.069).

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Authors' contributions

Conceptualization and study design, and initial draft preparation: Mohsen Miarkiani and Azar Mehri; Data collection: Mohsen Miarkiani; Data analysis and interpretation: Azar Mehri and Shohre Jalaei; Statistical analysis: Shohre Jalaei and Mohsen Miarkiani; Review, editing, and final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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