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Verbal fluency performance across different neurological disorders: a preliminary investigation

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Introduction. Language disorders can arise as a consequence of various neurological conditions, affecting communication and cognitive functioning. *Aim.* The aim of this study was to compare verbal fluency in individuals with different neurological disorders. *Method.* The sample consisted of 45 participants divided into three clinical groups according to the etiology: 15 post-stroke patients, 15 individuals with traumatic brain injury, and 15 patients with multiple sclerosis. The control group comprised 16 neurologically healthy participants. Phonemic and semantic verbal fluency tasks were administered. *Results.* Results indicated statistically significant differences in both phonemic and semantic fluency between each clinical group and the control group. Stroke patients demonstrated significantly lower performance on both phonemic and semantic fluency tasks compared to those with traumatic brain injury and multiple sclerosis. *Conclusion.* All three clinical groups with neurological disorders showed reduced verbal fluency abilities compared to healthy controls. These findings suggest that verbal fluency is frequently impaired across neurological disorders of different etiologies, regardless of clinical presentation.

Keywords: verbal fluency, stroke, traumatic brain injury, multiple sclerosis

Introduction

Language disorders may arise from various neurological diseases or injuries, particularly when brain regions critical for language processing are affected (Kristensson et al., 2024). In most individuals, the left hemisphere is

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dominant for language, and lesions in this hemisphere frequently lead to deficits across multiple language domains (Vuković, 2010, 2024).

Left-hemisphere lesions frequently cause aphasia, which is characterized by impairments in language production, comprehension, and the functional use of language. The specific presentation and severity of deficits depend on the lesion's location. For example, lesions in the frontal cortex, including the supplementary motor speech area, typically result in non-fluent aphasia, such as Broca's aphasia or transcortical motor aphasia (Vuković, 2024). In contrast, damage to the posterior part of the superior temporal gyrus may lead to a severe comprehension deficit, characteristic of Wernicke's aphasia (Sul et al., 2019; Vuković, 2010, 2024).

Verbal fluency refers to the ability to retrieve words based on phonemic or semantic cues and relies on both language functioning and broader cognitive processes (Kristensson et al., 2024). With regard to the underlying cognitive mechanism, it is generally hypothesized that phonemic fluency is primarily linked to executive abilities, whereas semantic fluency depends on the integrity of semantic memory (Rosser & Hodges, 1994). Performance on verbal fluency tasks also depends on verbal output capacity and processing speed (Godefroy et al., 2024).

Neuroimaging studies indicate that distinct cortical regions contribute to verbal fluency performance. The pars triangularis is primarily implicated in phonemic fluency, whereas semantic fluency engages the anterior temporal pole, corresponding to Brodmann's area 38 (Godefroy et al., 2023).

Deficits in verbal fluency have been documented in multiple neurological populations, including stroke patients, individuals with TBI, and those with neurodegenerative disorders (Vuković, 2024; Vuković, 2019a, 2019b). Reduced performance on verbal fluency tasks is closely associated with broader language impairments (Vuković & Chen, 2025).

Stroke patients may develop aphasia in 30 – 40% of cases following a cerebrovascular incident in the dominant hemisphere (Vuković et al., 2025). In milder forms of aphasia, patients often exhibit word-finding difficulties or object-naming deficits that do not conform to classical aphasic syndromes (Vuković, 2010). Language deficits in TBI similarly frequently manifest as word-finding difficulties, often associated with executive dysfunction resulting from diffuse axonal injury affecting both hemispheres (Chabok et al., 2012; Vuković, 2019a). In multiple sclerosis, language deficits have been reported, particularly in word retrieval during object-naming and verbal fluency tasks (Vuković, 2019b).

The aim of this study was to assess the phonemic and the semantic fluency in three clinical populations (stroke patients, individuals with TBI, and those with multiple sclerosis) and to compare their performance with that of healthy controls. We hypothesized that all clinical groups would demonstrate

lower verbal fluency than controls, and that differences in performance might also emerge among the clinical groups.

Methods

Sample

The study included 45 participants with neurological disorders: 15 post-stroke patients, 15 patients with traumatic brain injury (TBI), and 15 patients with multiple sclerosis (MS). The control group consisted of 16 neurologically healthy participants without hearing impairments or speech-language disorders. Demographic data of the participants are presented in Table 1.

The sample was formed using a non-random, convenience sampling method, with the participants providing informed consent. The clinical groups were recruited from the Rehabilitation Clinic "Dr. Miroslav Zotović". Inclusion criteria for clinical groups were: 1. stroke confirmed to the left hemisphere, TBI with diffuse axonal injury, or MS; 2. brain lesion confirmed by computed tomography (CT) or magnetic resonance imaging (MRI); 3. motivation to participate in the study.

Inclusion criteria for the control group were: absence of neurological, psychiatric, or speech-language disorders.

The mother tongue of all participants was Serbian. Written informed consent was obtained from all participants, and the study was approved by the Ethics Committee of the Clinic (decision number: 03-788/1).

Table 1

Demographic data of participants

Groups	Age (M/SD)	Years of education (mean)	Gender
Stroke patients	64.73 (13.41)	12.27	Male 53.33% (n = 8) Female 46.67% (n = 7)
Patients with MS	53.53 (14.45)	12.87	Male 46.67% (n = 7) Female 53.33% (n = 8)
Patients with TBI	49.07 (16.76)	12.00	Male 80% (n = 12) Female 20% (n = 3)
Control group	63.31(13.21)	12.81	Male 50% (n = 8) Female 50% (n = 8)

M – mean; SD – standard deviation

Results of the *t*-test indicated significant differences in mean age between stroke and TBI patients (p = .001), stroke and MS patients (p = .032), healthy controls and the TBI group (p = .008), and healthy controls and the MS group (p = .050). The *t*-test also showed that there were no significant differences in years of education across the examined groups.

The Chi-square test did not indicate significant gender differences between the tested groups (p = .114).

Procedure and Instruments

Information regarding the type of neurological disorder and brain lesions was obtained from patients' medical records. The stroke group included patients with ischemic strokes, all with CT or MRI-confirmed lesions in the cortex of the left hemisphere. Participants with right-hemispheric lesions were excluded. The TBI group included patients with MRI-confirmed diffuse axonal injury. The MS group included patients with MRI-confirmed chronic demyelinating changes in the basal ganglia or diffuse white matter lesions.

In all three groups of participants, the Serbian Aphasia Screening test (Vuković, 2010; Vuković et al., 2024) was used to exclude more severe forms of aphasia, while the Mini Mental State Examination – MMSE (Vuković, 2019b) was used to exclude patients with cognitive deficits.

The assessment

Verbal fluency was assessed using the *phonemic* and *semantic verbal fluency tests* (Benton & Hamsher, 1976; Spreen & Strauss, 1991). In the phonemic fluency task, participants were instructed to generate as many words as possible beginning with letters "K", "M", and "S" within a one-minute time frame per letter. Proper nouns, geographic terms, and numbers were excluded. In the semantic fluency task, participants were asked to generate as many animals as they could within one minute (Vuković, 2024). All clinical participants were tested at the Rehabilitation Clinic „Dr Miroslav Zotović ", while control participants were recruited conveniently from the examiner's immediate vicinity.

Statistical processing

Statistical analysis was conducted using IBM SPSS Statistics for Windows, version 26.0.

Descriptive statistics included frequency, percentage, median, arithmetic mean, standard deviation, minimum, maximum, and interquartile range. Group differences were evaluated using the Kruskal-Wallis test for multiple group comparison, with post-hoc analyses conducted using the Mann - Whitney test and two-factor ANOVA where appropriate.

Results

The results of the Serbian Aphasia Screening Test (SAST) showed that participants with stroke achieved an average score of 44.25 points (SD = 1.45) with reduced performance observed on the naming, repetition, reading, and writing tasks. Participants with TBI had an average score of 47.67 (SD =

1.70), while the average score in patients with MS was 47.85 (SD = 1.06). Both groups demonstrated reduced performance on the naming tasks. A statistically significant difference in the total SAST score was found between the stroke group and the other two clinical groups (p = .000).

The results of the MMSE showed that stroke patients had a total score of 27.20 points (SD = 1.15), TBI patients 28.40 (SD = 1.06), and MS patients 27.73 points (SD = 1.49). The differences in scores were not statistically significant (p = .270).

Performance on the verbal fluency tests

The results are presented first for each group individually, followed by the between-group comparison. Firstly, phonemic fluency was analyzed separately for each phoneme (K, M, S) and for the total score (Table 2). Secondly, semantic fluency performance was measured (Table 3).

Phonemic fluency

Table 2

Number of words produced on the phonemic verbal fluency test

Phonemes	Groups	M	SD	Min	Max	Mdn	IQR
K	Stroke	4.20	3.05	0	9	5.00	5.00
	MS	5.20	3.76	2	15	4.00	4.00
	TBI	5.73	3.35	2	15	5.00	3.00
	Control group	11.75	3.51	5	16	12.50	5.75
M	Stroke	3.20	2.34	0	7	3.00	4.00
	MS	4.00	2.48	1	10	4.00	3.00
	TBI	4.00	1.69	2	7	4.00	3.00
	Control group	9.13	4.33	2	16	9.00	7.00
S	Stroke	5.13	4.36	0	17	4.00	4.00
	MS	5.80	3.28	2	12	6.00	6.00
	TBI	4.60	1.88	1	8	4.00	2.00
	Control group	10.69	4.66	2	19	10.50	4.75
Total score	Stroke	12.53	8.58	0	30	13.00	10.00
	MS	15.00	8.82	5	37	13.00	11.00
	TBI	14.33	5.74	7	27	13.00	8.00
	Control group	31.56	11.68	9	51	32.50	15.25

M – mean, SD – standard deviation, Min – minimum, Max – maximum, Mdn – median, IQR – interquartile range

The Kruskal-Wallis test indicated statistically significant differences among the groups on the phonemic fluency test (H = 21.15, df = 3, p = .000).

Post-hoc comparison using the Mann-Whitney test revealed that:

- Stroke patients produced significantly fewer words than controls for all phonemes: K ($U = 16.00$, $p < .001$), M ($U = 30.00$, $p < .001$), S ($U = 42.00$, $p < .01$), and in the total score ($U = 25.00$, $p < .01$).
- MS patients scored significantly lower than controls for all phonemes: K ($U = 24.50$, $p < .001$), M ($U = 38.50$, $p = .001$), S ($U = 47.00$, $p < .01$), and in the total score ($U = 31.50$, $p < .001$).
- TBI patients also performed significantly worse than controls for all phonemes: K ($U = 28.50$, $p < .001$), M ($U = 40.00$, $p = .001$), S ($U = 27.00$, $p < .001$), and in the total score ($U = 25.50$, $p < .001$).

Semantic fluency

Table 3

Number of words produced on the semantic fluency test

Semantic fluency	Groups	M	SD	Min	Max	Mdn	IQR
Animals	Stroke	9.20	5.76	0	19	9.00	10.00
	MS	10.93	3.99	5	19	10.00	3.00
	TBI	10.07	4.74	4	20	10.00	9.00
	Control group	17.13	6.06	7	29	17.00	8.00

M – mean, SD – standard deviation, Min – minimum, Max – maximum, Mdn – median, IQR – interquartile range

The Kruskal-Wallis test showed statistically significant differences among the groups in the semantic fluency test ($H = 14.92$, $df = 3$, $p < .01$).

Mann-Whitney post-hoc analyses indicated that the control group produced significantly more words than stroke patients ($U = 42.50$, $p < .01$), MS patients ($U = 48.00$, $p < .01$), and TBI patients ($U = 39.50$, $p = .001$).

Discussion

This study examined verbal fluency in patients with three groups of neurological disorders: stroke, traumatic brain injury (TBI), and multiple sclerosis (MS), with the aim of establishing their performance on phonemic and semantic fluency tasks in comparison to a control group of neurologically healthy individuals.

The results indicate that stroke patients scored significantly lower than healthy controls on both phonemic and semantic verbal fluency tasks. Specifically, stroke patients produced approximately three times fewer words on the phonemic verbal fluency task and nearly twice as few words on the semantic fluency task compared to the control group. These findings suggest that phonemic fluency represents a more challenging task than semantic fluency. Similar patterns have been reported by Vuković and Stanković (2023), who

observed that older neurologically healthy adults performed worse on phonemic than on semantic fluency tasks.

Given that the stroke patients exhibited a mild form of aphasia, these results indicate that phonemic fluency is a particularly sensitive measure for detecting language deficits in this neurological group. Similar findings have been reported by other researchers, who observed impaired performance on phonemic fluency tasks in post-stroke individuals (Leggio et al., 2000; Babulal, 2016).

Participants with TBI demonstrated significantly lower verbal fluency scores compared to healthy controls, producing nearly half as many words on the phonemic task. Semantic fluency was similarly impaired. While some studies have reported no significant differences between TBI and neurotypical subjects (Wauters, Marquardt & Muñoz, 2019), other researchers indicate that moderate to severe TBI is associated with markedly impaired verbal fluency, particularly on phonemic fluency tasks (Cralidis & Lundgren, 2014; Mehri et al., 2017).

Participants with MS also demonstrated reduced verbal fluency compared to healthy controls, with significantly lower mean scores on both phonemic and semantic tasks. These results are consistent with previous studies reporting verbal fluency deficits in the MS population (Barois et al., 2021; Henry & Beatty, 2006). Barois et al. (2021) additionally observed delayed imitation, slower revival before task switching, and longer inter-word latencies in MS participants.

In our study, MS participants produced an average of 15 words on the phonemic fluency task and 10.93 words on the semantic task. These findings differ from those of Ebrahimipour et al. (2008), who reported lower phonemic fluency (5.88 words) but higher semantic fluency (15.03 words) in MS participants compared to controls. Some researchers have suggested that reduced verbal fluency in MS may be attributed to language impairments, slower cognitive processing, and executive dysfunction (Viterbo et al., 2013; Pitteri et al., 2023; Vuković, 2019b).

Across the clinical groups, stroke participants exhibited the lowest mean verbal fluency scores relative to those with TBI and MS. Interestingly, participants with TBI and MS produced similar numbers of words across tasks.

Previous research has reported significantly lower semantic verbal fluency performance in stroke patients compared to individuals with language disorders following TBI (Kristensson et al., 2024; Vuković et al., 2008). Based on their findings, Vuković et al. (2008) proposed that semantic fluency tasks may serve as a differential diagnostic tool to distinguish post-stroke aphasia from language deficits resulting from TBI. Since our study included patients with mild forms of post-stroke aphasia, we consider that semantic verbal fluency alone cannot reliably differentiate mild aphasia from posttraumatic language deficits. However, increasing the number of patients with mild post-stroke

aphasia and mild posttraumatic language deficits may provide more precise information regarding the significance of verbal fluency tests in differential diagnosis.

Limitations

This study included a relatively small number of participants within each clinical group, and precise lesion location data were not available.

Future research could aim to include larger samples and explore the relationships between verbal fluency, semantic memory, executive functions, and broader language abilities in post-stroke, TBI, and MS populations.

Conclusion

Verbal fluency is significantly impaired in patients with stroke, TBI, and those with multiple sclerosis. All three neurological groups achieved significantly lower scores on phonemic and semantic verbal fluency tasks compared to a neurologically healthy control group. Stroke participants exhibited lower verbal fluency performance than participants with TBI and MS. Considering that only stroke patients had mild forms of aphasia, we suggest that their reduced performance on verbal fluency tests is primarily linked to language impairments.

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Verbalna fluentnost kod različitih neuroloških poremećaja: preliminarno istraživanje

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Uvod: Jezički poremećaji mogu nastati kao posledica različitih neuroloških stanja, utičući na komunikaciju i kognitivne funkcije. *Cilj:* Cilj ove studije bio je utvrđivanje sposobnosti generisanja reči na zadacima verbalne fluentnosti kod osoba sa različitim neurološkim oštećenjima. *Metode*: Uzorak se sastojao od 45 ispitanika, koji su prema etiologiji neurološkog poremećaja podeljeni u tri kliničke grupe: 15 pacijenata koji su doživeli moždani udar, 15 ispitanika sa traumatskom povredom mozga i 15 pacijenata sa multiplom sklerozom. Kontrolnu grupu činilo je 16 neurološki zdravih ispitanika. U istraživanju su primenjeni testovi fonemske i semantičke verbalne fluentnosti. *Rezultati:* Rezultati su pokazali statistički značajne razlike u fonemskoj i semantičkoj fluentnosti između sve tri kliničke grupe i kontrolne grupe. Dalja analiza rezultata pokazala je da su pacijenti sa moždanim udarom postigli statistički značajno niže skorove na zadacima fonemske i semantičke fluentnosti u poređenju sa ispitanicima sa traumatskom povredom mozga i multiplom sklerozom. *Zaključak*: Sve tri grupe ispitanika sa neurološkim poremećajima ispoljile su sniženu sposobnost verbalne fluentnosti u poređenju sa kontrolnom grupom zdravih ispitanika. Ovi rezultati ukazuju na to da je verbalna fluentnost često oštećena kod neuroloških poremećaja različite etiologije, nezavisno od njihove kliničke slike.

Ključne reči: verbalna fluentnost, moždani udar, traumatska povreda mozga, multipla skleroza

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