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Cognitive performance and narrative discourse after SARS-CoV-2 infection

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ABSTRACT

Purpose: to evaluate cognitive performance and narrative discourse, as well as possible associations in individuals affected by COVID-19.

Methods: a cross-sectional exploratory research involving individuals infected by COVID-19 and hospitalized in the State of Sergipe. Participants underwent anamnesis, the Mini-Mental State Examination, Neupsilin and Montreal Toulouse Language Assessment Battery Collection (MTL/Brazil). The statistical tests employed were the Shapiro-Wilk test to assess the normality of data distribution, the nonparametric Mann-Whitney test for comparing two independent samples, and Spearman's correlation to evaluate the monotonic relationship between variables. The significance level was set at $P < 0.05$.

Results: thirty-two individuals participated in the anamnesis (75% males, 25% females). A significant correlation was found between the working memory and discourse skills ($P < 0.01$). Discourse analysis using the Mann-Whitney test revealed significant differences in the total number of scenes ($P = 0.005$; $d = 0.5$) and the total number of Information Units ($P = 0.017$; $d = 0.3$). These findings suggest that COVID-19 has a substantial impact on speech, affecting verbal fluency, auditory span, digit sequencing, and working memory, thereby influencing memory storage and retrieval processes.

Conclusion: the impact of the pandemic in this area covers a wide range of cognitive and discursive skills.

Keywords: SARS-CoV-2; Cognition; Memory; Language

A study conducted at the Universidade Federal de Sergipe, Lagarto, SE, Brazil.

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INTRODUCTION

From March 2020 to May 2023, the world faced a public health emergency. The COVID-19 pandemic changed the habits and routines of the global population, leading health agencies to take drastic measures to contain its spread[1]. Over the months, several studies have sought to better understand the behavior of SARS-CoV-2, including its family, origin, pathophysiology, treatment, and short- and long-term consequences. To date, it is known that the virus belongs to the coronavirus family, subgenus *Sarbecovirus,* and that it spreads through airborne droplets, facilitating its transmission and rapid progression[2,3].

During the pandemic, the number of confirmed COVID-19 cases worldwide exceeded 694 million, with approximately 6.91 million deaths[4]. In Brazil, the number of recorded deaths was notable, totaling more than 705 thousand, with a fatality rate of 1.9%, second only to the United States and ahead of countries with larger populations, such as India[4]. Factors contributing to this scenario include the delay in the start of vaccination compared to other developed countries, the spread of fake news related to the infection, and the emergence of new mutations and variants of SARS-CoV-2[4,5].

The rapid proliferation and prevalence of SARS-CoV-2 are related to several factors, such as its structure, as the virus is composed of four proteins that play vital roles in various physiological functions of the human body. These proteins enable the virus to replicate in multiple tissues, facilitating both viral replication and cytokine communication with the host[6,7]. Furthermore, risk factors related to the development of the severe form of COVID-19, such as advanced age, genetic variation, comorbidities, frailty, and socio-demographic factors, also contribute to the disease's proliferation[8].

After the World Health Organization declared the end of the COVID-19 public health emergency and the subsequent increase in the number of people vaccinated globally, a reduction in infection cases and mortality was observed[9]. With the public health emergency under control, attention turned to the consequences generated by the pandemic period, including cognitive and sensory deficits, cardiovascular diseases, chronic fatigue syndrome, and cerebrovascular diseases[10,11].

Among these sequelae, cognitive impairment associated with COVID-19 has been extensively studied during the pandemic years. Impairments in memory, attention, executive functions, speech, depression, and anxiety are directly related to the severity of SARS-CoV-2 infection[12]. Furthermore, pre-existing comorbidities, such as diabetes and hypertension, age, and other risk factors for developing the severe form of COVID-19 have been associated with the development of long-term sequelae, known in the literature as "Long-COVID"[13,14].

Regarding the long-term sequelae presented after SARS-CoV-2 infection, the impairment of communication skills stands out. This impairment has been linked to the aforementioned cognitive abilities and to neurological sequelae, such as cerebral hypoxia, aphasia, cerebrovascular and thrombotic diseases[15,16]. Such impairments have been associated with the cellular mediator of SARS-CoV-2, the enzyme ACE2, which is expressed in several regions of the central nervous system, such as the motor cortex, olfactory bulb, and vagus nerve. This helps explain the wide range of impaired cognitive abilities following COVID-19[17,18].

Several communication skills are correlated with cognitive aspects and, consequently, may be affected by SARS-CoV-2. Among these skills is discourse, a verbal macrostructure that requires a complex ability to select and sequence semantic units, involving skills such as social cognition and working memory[19]. Deficits in this discursive skill can impair learning, limit participation and social interaction, and impact emotional well-being, personal development, and interpersonal relationships[20].

In this context, there is still insufficient evidence on the cognitive and discursive aspects related to COVID-19. This means that these complaints are poorly understood, and the impact of the pandemic on the different functions of the human body remains unknown. Therefore, the hypothesis of this study is that people infected with SARS-CoV- 2 are more likely to present impairments in cognitive function and discourse. Thus, this study aimed at evaluating cognitive performance and narrative discourse, as well as possible associations in individuals affected by COVID-19, so as to improve the understanding of sequelae that have not yet been studied.

METHODS

Study design and ethical aspects

This observational, cross-sectional study employs a quantitative analysis of the results. It adheres to the recommendations outlined in the STROBE

guidelines[21] and Resolution 466/12 of the National Health Council. The study was approved by the Research Ethics Committee of the Federal University of Sergipe, Brazil (approval number 5658792; CAAE 61448422.7.0000.0217). Data collection occurred between January and November 2023 at the Adult and Elderly Communication Outpatient Clinic of the university.

Eligibility criteria

People of any gender were included in the study: residents born in Brazil, aged 18 or over, who were hospitalized for COVID-19 at the University Hospital in the municipality of Lagarto and at the Surgical Hospital in the city of Aracaju, Brazil. Individuals were excluded if, at some point during the research, they withdrew their free and informed consent, had difficulty answering the oral questionnaires, had cognitive impairment prior to hospitalization, were bedridden due to mobility problems that made their participation in the research difficult, tested positive for COVID - 19 during assessments (due to the need to adhere to isolation protocols and potential interference with test results during the acute phase of the disease), or used psychoactive drugs (including sleeping pills) without a medical prescription.

Research procedures

Testing for COVID-19

Participants underwent the iChromaTM COVID-19 Ag PCR test for COVID-19. During this stage, the team received assistance from a pharmaceutical professional who used personal protective equipment throughout the sample collection, storage, and handling processes. The product was stored at the temperature recommended by the manufacturer (below 30°C)[22]. Results were reported as either 'detected' (positive) or 'not detected' (negative). Individuals testing negative proceeded to the next stage.

Anamnesis

An oral interview was conducted with the research participants, and their data were recorded on a separate sheet. Information was collected on socioeconomic, identification, and discourse-language pathology complaints pre- and post-COVID-19 infection.

Mini-Mental State Examination - MMSE-2

For cognitive screening, the red abbreviated version of the MMSE-2 was utilized[23]. This test encompasses aspects including temporal and spatial orientation, immediate memory, attention and calculations, recall memory, language, and visual constructive ability. The analysis of the results was carried out using T scores, wherein the outcomes were converted, considering the age and years of study of each participant.

Brief Neuropsychological Assessment – Neupsilin

Cognitive function was assessed using the Brief Neuropsychological Assessment Instrument - Neupsilin, applicable to individuals aged 12 to 90 years, regardless of their neurological condition[24]. Neupsilin is validated and consists of 32 subtests that encompass eight distinct neuropsychological functions: Temporal-Spatial Orientation, Concentrated Attention, Visual Perception, Arithmetic Skills, Oral and Written Language, Verbal and Visual Memory, Praxis, and Executive Functions.

In this research, the assessments were conducted by a team of adequately trained discourse therapists. The test scores were converted following the calculation of the Z score, and for the quantitative analysis of the data, they were categorized into levels such as superior, medium, deficit alert, deficit, moderate-severe deficit, and severe deficit. Participants classified as medium and superior were considered normal, while the other classifications were considered altered.

Montreal Toulouse Language Assessment Battery Collection – MTL/Brazil

Discourse was assessed using the Montreal Toulouse Language Assessment Instrument - MTL/Brazil Collection (MTL), which comprises 22 tasks covering oral and graphic emission, oral and graphic comprehension, as well as non-verbal praxis and calculation[25]. Exclusively, task 4 was employed during data collection, with the aim of evaluating oral discourse through the description of a 'bank robbery' scene.

The quantitative analysis was conducted based on the criteria established by the authors, considering the total number of words in the discourse, as well as the number of information units (IU). These IUs correspond to the words previously defined by MTL/Brazil, encompassing elements present in the analyzed image, such as bank, money, police, van, warn, and person. The evaluation is performed based on the total number

of UIs identified in the presented discourse, ranging from 0 to 10 points. The last parameter evaluated in this task was the total number of scenes evoked during the discourse. The presence of three scenes pre-established by MTL/Brazil, related to the presented discourse, was analyzed, with scores ranging from 0 to 3. The pre-defined scenes were as follows: "Assault inside the agency," "Someone waiting for the criminals outside," and "Someone calling/notifying the police." For the quantitative analysis, the results were converted using the z-score calculation, which takes into account the age, years of study, and standard deviation of each individual analyzed. Its classification can be superior, average, deficit alert, deficit, moderate-severe deficit, and severe deficit.

BIAS

To avoid selection bias, participants who were on the list of people affected by COVID-19 and admitted to the hospitals in question were recruited. Additionally, people with severe cognitive impairment were excluded to prevent potential confounding effects on the results. All tools used were validated for the respective outcomes.

Statistical analysis

The sample selection was done for convenience, and the independent quantitative variables analyzed were age and education. Education was divided into high and low levels, where 1 to 8 years of study were considered a low level, and 9 years onwards were considered a high level. The dependent variables analyzed included the oral discourse test from the MTL/Brazil, as well as working memory tests, auditory span of words in sentences, verbal fluency, and ascending ordering of digits from the Neupsilin.

Data analysis was carried out using Jamovi software. For subsequent analyses, the effect size was considered, categorized as large (0.5), medium (0.3), and small (0.1), and the results were presented as mean, standard deviation, and median[26]. The choice of statistical tests used was determined based on the distribution of the sample, as verified by the Shapiro-Wilk test to ascertain whether it follows a normal distribution or not. For the subsequent analysis of the evaluated protocols, results classified as superior and average were considered normal, whereas deficit alert, deficit, moderate-severe deficit, and severe deficit were defined as altered.

RESULTS

783 participants were recruited from the hospitals in question. Only 68 responded to calls to participate in the survey. After this, 20 participants were excluded due to severe cognitive impairment and 13 refused to participate. Of the remaining 35, three participants refused to continue the evaluations, thus a total of 32 people participated in this study. See details in Figure 1.

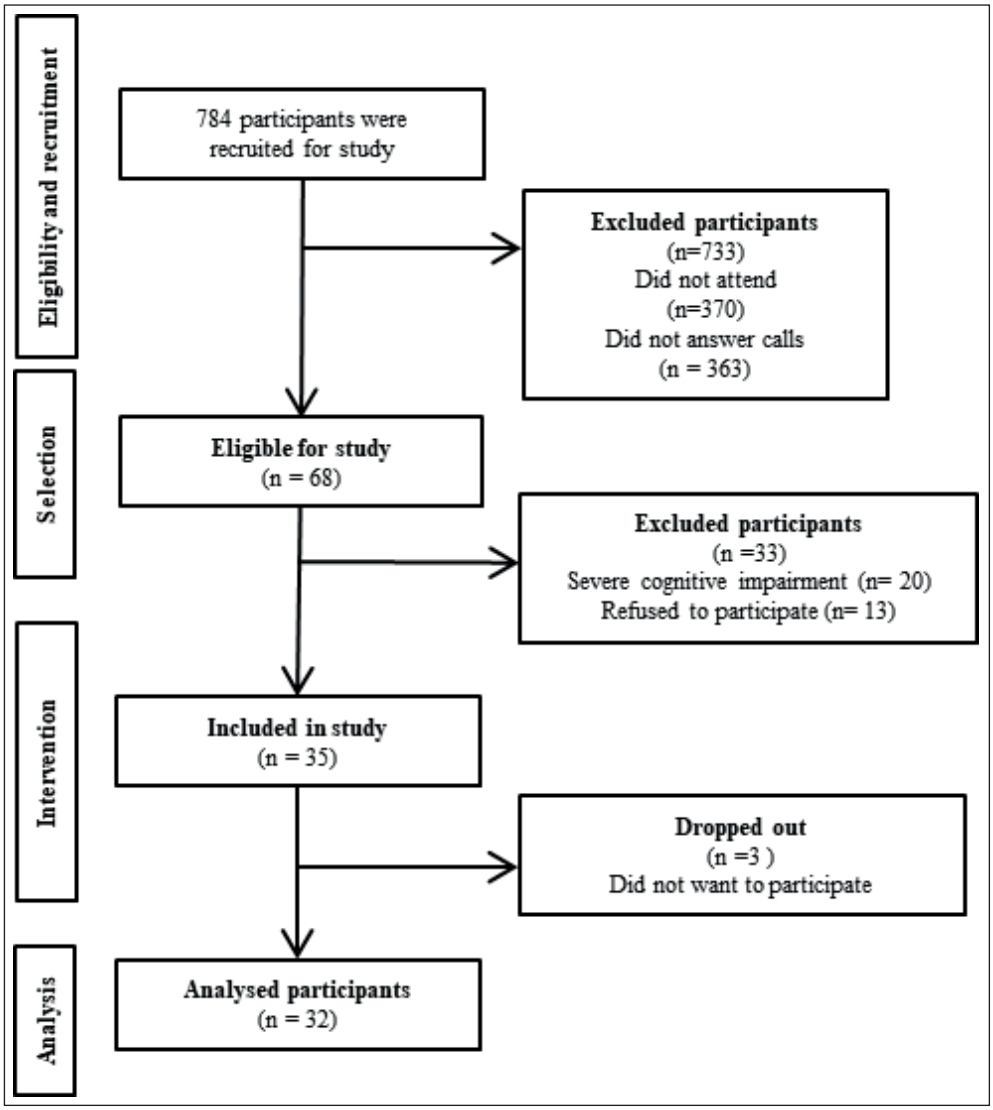

Figure 1. Flowchart of recruitment and selection of participants for the study

The sample consisted of a total of 32 participants, of whom 75% were males and 25% were females. The average age was 51.6 ± 13.6 years, with an average of 8.41 ± 3.77 years of study. Among the assessments conducted during the research, verbal fluency and total UI showed changes in 53.13% of cases after calculating the z-score, with these two being the ones that demonstrated the greatest changes. Table 1 provides a description of participant characteristics and applied protocols.

Table 1. Description of participants and protocols

	Mean (SD)
Age	
Female participants	57.75 (14.22)
Male participants	49.54 (13.10)
Years of study	
Female participants	6.8 (3.09)
Male participants	8.92 (3.90)
	N (%)
Gender	
Feminine	8 (25)
Masculine	24 (75)
Applied protocols	N (%)
MTL - Number of words	
Normal	23 (71.87)
Changed	9 (28.13)
MTL - Total UI	
Normal	15 (46.87)
Changed	17 (53.13)
MTL - Total scenes	
Normal	20 (62.5)
Changed	12 (37.5)
NEU- Working Memory	
Normal	18 (56.25)
Changed	14 (43.75)
NEU-Ascending ordering of digits	
Normal	17 (53.13)
Changed	15 (46.87)
Auditory NEU-Span of words in sentences	
Normal	16 (50)
Changed	16 (50)
NEU-Verbal fluency	
Normal	15 (46.87)
Changed	17 (53.13)

Captions: UI - information units; MTL - Montreal Toulouse Language Assessment Battery Collection; NEU- Brief Neuropsychological Assessment – Neupsilin.

Table 2 describes the performance of the MTL in relation to the age range of the participants, categorized as adults and older people. The statistical calculation used was the Mann-Whitney non-parametric test. It was possible to observe statistically significant differences in the total number of scenes and total UI, with an effect size considered large (0.5) for the total number of scenes, medium for the total UI (0.3), and small for the number of words (0.1)[26].

Table 2. Discourse performance in relation to age

		Statistics	p-value		Effect Size
MTL - Total IU	U de Mann-Whitney	65.0	0.017	Biserial ordercorrelation	0.4922
MTL - Number ofwords	U de Mann-Whitney	121.5	0.821	Biserial ordercorrelation	0.0508
MTL - Total scenes	U de Mann-Whitney	56.5	0.005	Biserial ordercorrelation	0.5586

Captions: UI - information units; MTL - Montreal Toulouse Language Assessment Battery Collection.

Regarding the discourse results, when comparing different levels of education, it was observed that participants with a higher educational level demonstrated superior performance in both the total number of Information Units (IU) and total scenes. However, no statistically significant difference was identified in the number of words. Table 3 outlines the relationship between discourse and the level of education.

Table 3. Relationship between education level and discourse.

	Education level	N	Average	Standard error	Median	Standard deviation
MTL - Number of words	High	16	39.250	6.106	38.50	24.425
	Low	16	42.875	5.484	42.50	21.936
MTL - Total IU	High	16	5.500	0.619	5.50	2.477
	Low	16	4.000	0.577	3.00	2.309
MTL - Total scenes	High	16	1.875	0.239	2.00	0.957
	Low	16	0.813	0.209	1.00	0.834

Captions: UI - information units; MTL - Montreal Toulouse Language Assessment Battery Collection

Table 4 describes the correlation between the quantitative variables analyzed: discourse and verbal fluency tests, working memory, digit ordering, and auditory span of words in Neupsilin sentences. It was observed that verbal fluency is not correlated with working memory and discourse variables. On the other hand, working memory and discourse exhibit a strong correlation.

Table 4. Discourse correlation matrix with working memory, ascending ordering of digits, auditory span and verbal fluency.

		MTL - Number of words	MTL - Total IU	MTL - Total scenes
NEU- Working Memory	Rho de Spearman	0.145	0.493	0.607
	gl	30	30	30
	p-value	0.429	0.004	< 0.001
NEU- Ascending ordering of digits	Rho de Spearman	0.174	0.338	0.438
	gl	30	30	30
	p-value	0.341	0.058	0.012
NEU- Auditory span of words in sentences	Rho de Spearman	0.123	0.479	0.595
	gl	30	30	30
	p-value	0.501	0.006	< 0.001
NEU- Verbal fluency	Rho de Spearman	0.280	0.223	0.192
	gl	28	28	28
	p-value	0.134	0.236	0.310

Captions: UI - information units; MTL - Montreal Toulouse Language Assessment Battery Collection; NEU- Brief Neuropsychological Assessment – Neupsilin.

DISCUSSION

This study aimed to evaluate cognitive performance and narrative discourse, as well as their possible associations, in individuals affected by COVID-19. Thirty-two participants were included, most of whom were male. Among the outcomes evaluated, discourse and verbal fluency were the ones that showed significant changes. Additionally, working memory and discourse exhibited a strong correlation, while verbal fluency did not correlate with any of the analyzed variables.

A review of the literature reveals a gap in understanding the correlation between cognitive aspects such as working memory, verbal fluency, and narrative discourse in the context of COVID-19. Therefore, this study is pioneering and provides robust evidence for tracking and understanding impairments in cognitive function in people infected with SARS-CoV-2 through quantitative assessment of discourse and cognitive aspects.

Systematic reviews demonstrate a direct relationship between SARS-CoV-2 infection and cognitive alterations[27,28]. These changes are also associated with secondary factors related to COVID-19, such as metabolic disorders, systemic inflammation, and cerebral hypoxia, which can lead to impairments in cognitive abilities like language, memory, attention, learning, speech, and verbal fluency [29,30]. Cognitive dysfunction may occur due to direct infection of neurons by the virus via angiotensin-converting enzyme 2 (ACE2), loss of gray matter, and clearance of brain metabolites (beta-amyloid peptides) post-infection[29,30].

The neurological manifestations and symptoms of SARS-CoV-2 infection can vary greatly depending on the condition and severity of the disease. Among the most common are hypogeusia and anosmia (changes in taste and smell), encephalitis, and an increase in cases of stroke[31]. Furthermore, short- and long-term communicative sequelae have been observed in several studies. Some authors attribute these changes to factors related to the duration of hospitalization and complications encountered during this period. Specifically, long-term intubation combined with reduced family interaction due to preventive measures aimed at containing the virus has been linked to an increase in cases of impaired communication skills[31-33].

Based on this premise, few studies have linked narrative discourse to cognitive function in people affected by COVID-19. In other populations with impaired cognitive function, such as those with dementia and aphasia, these impairments have been correlated with deficiencies in narrative discourse. This is because skills such as attention, working memory, executive functions, and problem-solving are crucial for effective discursive performance[34,35]. Another relevant study by Kertesz et al., which used the 'Picnic Scene' from the Western Aphasia Battery, demonstrated that performance in discursive tasks directly influences executive functions[35]. These findings reinforce the results of our study, which observed a strong correlation between working memory and narrative discourse.

Cognitive analysis is crucial as it provides insights into several components essential for daily activities, including access to stored information, processing of executive functions, working memory, short-term auditory memory, and language processing[36]. Studies indicate that changes in these components can lead to impairments in communication, concentration, learning, problem-solving, and decision-making[37,38]. Over time, these impairments can result in the decline of other skills, such as oral and written language, and affect memory subsystems[39]. In the present study, a higher number of participants exhibited changes in working memory and verbal fluency, suggesting that these individuals may face difficulties in daily activities, which could negatively impact their quality of life and social participation.

This study presents limitations, including a small sample size, lack of longitudinal follow-up, absence of well-being and quality-of-life assessments, and low adherence from the target population. Despite these limitations, the data obtained offer valuable insights for the fields of psychology, speech-language pathology, and psychiatry. The analysis of cognitive and discursive aspects can support not only differential diagnosis but also the formulation of therapeutic goals, assessment procedures, and treatment planning for individuals presenting with narrative discourse or cognitive impairments[40]. These findings also pave the way for future research, inspiring and motivating the audience to continue the exploration of this important area.

The results underscore the importance of integrating the assessment and rehabilitation of cognitive and communicative functions, particularly working memory and narrative discourse, into post-COVID-19 care protocols. These functions are essential for personal autonomy, social participation, and overall quality of life. In this context, the study highlights the crucial role of interdisciplinary strategies involving speech-language pathologists, psychologists, and other

healthcare professionals. This collaborative approach is vital for the early identification of deficits and the implementation of targeted interventions, making the audience feel included and part of a larger community working towards a common goal.

CONCLUSION

It is concluded that participants infected by SARS-CoV-2, who required hospitalization in the smallest state in the northeast of Brazil, presented changes in discourse and cognitive aspects related to verbal fluency, auditory range, digit ordering and working memory. Furthermore, it was observed that changes in discursive skills were positively correlated with cognitive aspects, such as working memory and verbal fluency.

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Authors' contribution:

FOS: Conceptualization; Data curation; Formal analysis; Visualization; Writing - Original draft; Writing - Review & editing.

PJAC: Conceptualization; Investigation; Methodology.

CPHARC: Conceptualization; Investigation; Methodology; Project administration.

RCMC: Conceptualization; Investigation; Project administration

FOAS: Conceptualization; Methodology, Visualization; Writing - Original draft.

RBGG: Conceptualization; Project administration; Supervision.

NMS: Conceptualization; Investigation; Methodology; Project administration.

KS: Conceptualization; Data curation; Funding acquisition; Supervision.

Data sharing statement:

When requested, only legally permitted data will be share with other authors for research purposes.