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Macrostructural aspects in oral narratives in Brazilian Portuguese by left and right hemisphere stroke patients with low education and low socioeconomic status

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Abstract

Objective: Individuals with a stroke in either the left (LH) or right hemisphere (RH) often present macrostructural impairments in narrative abilities. Understanding the potential influence of low education and low socioeconomic status (SES) is critical to a more effective assessment of post-stroke language. The first aim was to investigate macrostructural processing in low education and low SES individuals with stroke in the LH or RH or without brain damage. The second aim was to verify the relationships between macrolinguistic, neuropsychological, and sociodemographic variables.

Methods: Forty-seven adults with LH (n = 15) or RH (n = 16) chronic ischemic stroke and 16 matched (age, education, and SES) healthy controls produced three oral picture-sequence narratives. The macrostructural aspects analyzed were cohesion, coherence, narrativity, macropropositions, and index of lexical informativeness and were compared among the three groups. Then, exploratory correlations were performed to assess associations between sociodemographic (such as SES), neuropsychological, and macrostructural variables.

Results: Both LH and RH presented impairments in the local macrostructural aspect (cohesion), while RH also presented impairments in more global aspects (global coherence and macropropositions). All five macrostructural variables correlated with each other, with higher correlations with narrativity. Naming was correlated with all macrostructural variables, as well as pre-stroke reading and writing habits (RWH), showing that higher naming accuracy and higher RWH are associated with better macrostructural skills.

Conclusion: The present results corroborate the role of the LH in more local processing and the RH in more global aspects of discourse. Moreover, the study highlights the importance of investigating discourse processing in healthy and clinical populations of understudied languages such as Brazilian Portuguese, with various levels of education, SES, and reading and writing habits.

Keywords: discourse; narratives; chronic stroke; macrostructure; sociodemographic; socioeconomic status; right hemisphere; left hemisphere; reading habits.

Introduction

Stroke is a cerebrovascular disease and a major cause of disabilities, with a direct impact on families' organization and on public health and retirement systems. Specifically in Brazil, 70% of people who had a stroke do not return to their professional activities (Sociedade Brasileira de Doenças Cerebrovasculares, n.d.) and half of them lose autonomy and must receive support from family members or caregivers to accomplish their daily activities (Agência Brasil, 2020). Stroke also seems to be more prevalent in low-income and middle-income countries as compared to high-income ones (Avan et al., 2019; Bray et al., 2018). Not only is the risk of having stroke higher in these countries but also stroke functional outcomes are lower due to the quality of stroke care in hospitals and rehabilitation centers in developing countries (Carlos et al., 2019; Marshall et al., 2015). Some sociodemographic aspects related to socioeconomic status (SES) may also impact the risk and prevalence of stroke, among them urban versus rural residence, occupational class, income level, and education (Zhou et al., 2020). In fact, studies have shown that lower education levels may predict the mortality rate associated with stroke (Ahacic et al., 2012).

Although stroke seems to be more prevalent and disabling in low-income and middle-income countries, very few studies have been conducted on post-stroke discourse production impairments in underdeveloped or developing countries. In fact, most studies conducted to date on post-stroke language impairments have been conducted on English-speaking individuals (Beveridge & Bak, 2011). Very few studies have been conducted to date in developing countries, which have lower education according to the education index of the Human Development Reports (United Nations Development Programme, 2020), than the countries in which most studies on post-stroke language impairments have been conducted to date. For instance, among the rare studies conducted to date looking at the effect of education, the mean level of education of 12 years and patients with less than 10 years of education were not tested with written stimuli (González-Fernández et al., 2011). Although low SES individuals represent the majority of people in developing countries, studies investigating the impact of low SES on oral narratives following a stroke are still

scarce. Among the few published studies, Song et al. (2017) reported that people with lower SES—measured by indexes such as the level of education, occupation, and income—present poorer functional outcomes following an ischemic stroke.

Current knowledge highlights the urgent need to investigate stroke outcomes, including communication abilities, in people with low SES. The capacity to produce and understand language in context is vital to properly engage in social activities (Dalemans et al., 2010) and communication in everyday life requires the recruitment of language and cognitive skills. Although most communication outputs are beyond the word level, spoken discourse has received less attention than single word tasks, as it requires more complex and time-consuming analyses and interpretation (Boles, 1998). Description of sequences of pictures, for example, is more congruent with everyday language use than are single picture description tasks. Despite still being very different from a conversation, spoken description of sequences of pictures offers a relatively ecological evaluation of language impairments as compared to single word production tasks (Boles, 1998; Bryant et al., 2016). In the last decade, a growing body of literature has emerged regarding spoken discourse, which is now considered one of the most ecologically valid assessments of language impairments (Brisebois et al., 2021). Discourse performance relates to social participation, which makes it a key language component according to the International Classification of Functioning, Disability, and Health (ICF) model (Armstrong et al., 2012).

The ability to produce spoken discourse comes effortlessly and naturally to most individuals. Nevertheless, it involves a complex interplay of cognitive, linguistic, and sociodemographic variables. Age and education are amongst the most studied factors influencing spoken discourse in typical aging. Nonetheless, age-related features in spoken discourse production remain inconclusive. Conversely, the effect of education seems to differ depending on the measures analyzed in the different discourse genres. For example, level of education did not affect the macrostructural parameters evaluated in conversation, whereas individuals with lower education levels differed in microstructural variables as compared to higher education individuals (Mackenzie, 2000). More specifically, shorter and

less complete picture descriptions were produced by individuals with minimal levels of education. Reading and writing habits (RWH) are also closely linked to the level of education, but individuals with low levels of education can still have rich and frequent reading and writing activities. In a unique study conducted in Brazil, Pawlowski et al. (2012) demonstrated the association between the frequency of RWH and cognitive abilities. They reported that frequent reading and writing activities in individuals with low levels of formal education compensated for their performance in cognitive tasks. This highlights the importance of not only investigating the level of education but also including other variables which have an impact on cognitive performance. Moreover, the 14-year longitudinal study of Chang et al. (2021) showed that frequent reading habits were associated to a reduced risk of cognitive decline in a large group of older adults aged 64 and older at all educational levels. Also partly associated with education level, the impact of SES in linguistic and cognitive performance has been widely studied in preschool-aged (e.g., Attig & Weinert, 2020) and school-aged language learners (e.g., Alt et al., 2016), but has received very little attention in adults. Among the few studies conducted to date, SES has been associated with the quality of content and discourse productivity (Snow et al., 1997; Yorkston et al., 1993) as well as with cohesion (Coelho, 2002). Regarding the latter, professional and skilled workers had better scores on cohesion measures than unskilled workers, but no differences were found on sentence production measures and story grammar measures. Despite their clinical relevance, very few studies have been conducted on the discourse production abilities of stroke patients with low SES, low levels of education, and non-English speakers.

For purposes of analyzing oral discourse production, two main approaches have been proposed: (1) *structural* and (2) *functional* (Pritchard et al., 2017). In the *structural approach*, the focus is on discrete variables, which include macrostructural and microstructural processes, whereas the *functional approach* complements the structural approach by analyzing the ability to convey relevant and meaningful information at the discourse level. Macrostructural processes, or between-sentence functions, generate the

conceptual structure of the message that will be delivered (Marini, Andreetta, et al., 2011), whereas microstructural processes, or within-sentence functions, refer to phonological, lexical, semantic, and grammatical processing. Quantitative analysis of spoken discourse samples can provide valuable information about both microstructural and macrostructural aspects of language. While the analysis of microstructural variables is important, assessing performance on macrostructural measures, such as cohesion, coherence, and macropropositions, is also crucial. Moreover, the microstructural aspects can more easily be compared from one language to another using databases and automated procedures such as natural language processing (e.g., Karakanta et al., 2018; Marzouk, 2021).

The present article focuses on five variables of macrostructural processing, namely cohesion, coherence, macropropositions, narrativity, and index of lexical informativeness. From a *structural perspective*, we chose to investigate cohesion and coherence, two widely used measures of macrostructural processing, including studies with stroke populations (e.g., Barker et al., 2017; Davis et al., 1997; Stockbridge et al., 2021) as well as macropropositions, which have not yet been widely investigated. *Cohesion* refers to the structural and semantic connectivity between elements of speech which is accomplished by the use of cohesive devices (Halliday & Hasan, 1976). In other words, cohesion builds up a *continuity* of meaning, which is generally expressed by the relationship among *reiteration*, *association*, and *connection* (Antunes, 1996, 2005). *Coherence* refers to the ability to maintain the theme by producing propositions that have a harmonious progression (Barker et al., 2017). *Macropropositions* of narratives refer to the knowledge of the schematic structure of narrative stories, which includes hierarchically organized categories such as setting, complication, resolution, evaluation, and conclusion. This structure is well-known and used in everyday communication (Van Dijk, 1980). From a more *functional* perspective, the present study also targeted *narrativity* and *lexical informativeness*. On the one hand, *narrativity* is related to the *manner* by which narratives are orally produced. It consists of story structure, as well as skills crucial to creating a coherent narrative, such as the

predominance of narration (as opposite to a simple description of isolated scenes), the sole inclusion of pertinent aspects, which includes the recognition of the characters (Hübner et al., 2019). A successful storytelling relies on the recognition by the interlocutor of the sequence of the narrative structure, with its causal implications. The use of sequences of scenes allows the assessment of the individual's ability to construct narrative ties between the scenes, as opposed to single pictures, which tend to elicit descriptions instead (Davis et al., 1997). Our previous study (Schneider et al., 2021) was among the first to investigate narrativity in stroke patients. On the other hand, *lexical informative*ness has been investigated using different measures (Pritchard et al., 2017). Among them are lexical information units (LIUs), which are content and function words phonologically well-formed and appropriate from a grammatical and pragmatic point of view (Andreetta & Marini, 2015; Marini, Boewe, et al., 2005; Marini, Carlomagno, et al., 2005; Marini, Galetto, et al., 2011).

There is a consensus about the fact that the left hemisphere (LH) is dominant for language processing in the large majority of right-handed individuals (Knecht et al., 2000). However, an increasing body of evidence has shown that language processing not only is supported by the LH but, rather, subserved by a bilateral language network (e.g., Gainotti, 2016; Lindell, 2006; Sollmann et al., 2014). As a result, the role of the RH has gained increased attention in the last three decades, especially regarding the macrostructural variables in discourse production. According to the higher levels of discourse production representations (Barker et al., 2017), macrostructural processes have traditionally been associated with RH regions (Myers, 1999), whereas microstructural processes have been associated with the LH. Accordingly, converging evidence suggests that individuals with RH damage present difficulties in cohesion, coherence, and, consequently, discourse organization (see Brownell & Martino, 1998; Hough, 1990; Kempler, 1990; Molloy et al., 1990; Myers, 1999). More recently, Marini (2012) reported that participants with an RH lesion produced descriptions with normal levels of microstructural elements, whereas the levels of conveyed information were reduced compared to healthy participants' performance.

Although deficits in cohesion have been more consistently observed in a stroke located in the RH (Marini, Carlomagno, et al., 2005; Sherratt & Bryan, 2019; Stockbridge et al., 2019), cohesion impairments have also been reported in patients with a LH stroke (Andreetta et al., 2012; Barker et al., 2017; Davis et al., 1997; Ellis et al., 2005; Geranmayeh et al., 2017; Marini, 2012; Stockbridge et al., 2019; Uryase et al., 1991). In our preliminary study, we reported that patients with a stroke in the LH or RH produced a lower proportion of cohesive ties than controls, but the difference was significant only for the LH group (Schneider et al., 2021). Barker et al. (2017) hypothesized that impairments observed in cohesion in LH individuals might be caused by linguistic impairments rather than by macrostructural impairments per se. Our results did not support this hypothesis, but a moderate and positive correlation between these aspects has recently been reported in a group of older adults (Sherratt & Bryan, 2019). Therefore, the relationship between verbal fluency and cohesion requires further attention.

As mentioned previously, spoken discourse is considered a complex task (Ska et al., 2004), and its complexity varies across eliciting task typologies (Stark, 2019). More structured tasks, such as single-picture description, are easier to perform because performance relies less on memory and attention as compared to less structured tasks, such as having a conversation (Sherratt & Bryan, 2019). In line with Barker et al.'s (2017) representation of discourse, macrostructural processing involves the construction of a preverbal message, i.e., the generation of ideas and their organization, which is highly supported by executive functions. Indeed, non-linguistic cognitive mechanisms such as executive processes and attention, but also more affective aspects like social cognition and emotion, are implicated in the *conceptual preparation*. Evidence has also shown that story grammar (Mozeiko et al., 2011) and global coherence (Barker et al., 2017; Wright et al., 2014) are associated with measures of executive functions. The number of *lexical* cohesive ties was also moderately positively correlated with verbal fluency in a group of 32 older men (Sherratt & Bryan, 2019). Similarly, correlations between verbal fluency and global and local connectedness have also been reported in clinical populations such as individuals with the

behavioral variant of frontotemporal dementia (Ash et al., 2006) and individuals with amyotrophic lateral sclerosis (Ash et al., 2014). The most consistent correlations have been found between naming accuracy (in a naming task) and discourse variables, including macrostructural variables. Namely, correlations have been reported between naming accuracy and informativeness in the acute (Boucher et al., 2020) and chronic phases (Fergadiotis & Wright, 2016) of post-stroke aphasia. Correlations have also been reported with main concept analysis in chronic post-stroke aphasia (Richardson et al., 2018). More recently, Alyahya et al. (2020) proposed a very interesting unified model of discourse processing but their study compared only patients with post-stroke aphasia (following a stroke in the LH) and controls. Using a principal component analysis, they showed that discourse production was composed of three main components, namely, verbal quantity, verbal quality (i.e., the component related to macrostructural processing), and motor speech. Using voxel-wise lesion-symptom mapping, they showed that verbal quality, which refers to informativeness in the present study, was associated with widespread frontal regions and superior temporal lobule. These regions have previously been associated with working memory (Boisgueheneuc et al., 2006) and executive functions (Humphreys & Lambon Ralph, 2015) and are consistent with the model of Barker et al. (2017), which suggests that the *conceptual preparation* level is supported by non-linguistic cognitive factors. Moreover, positive correlations between story grammar, a variable similar to the macropropositions measure used in the present study, and measures of executive functions have been reported (Mozeiko et al., 2011).

Another important consideration is that cognitive decline has been reported in normal aging (Drag & Bieliauskas, 2010). Most studies exploring the relationship between discourse processing in aging and cognitive functioning have used written discourse comprehension tasks (Ska et al., 2009). Among the studies conducted to date, it has been proposed that changes in narrative complexity and cohesion are associated with age-related decline in working memory (Kemper & Kemtes, 2012). In a more recent study, increased cohesive

errors and decreased referential ties have been shown with aging, which co-occurred with declining memory and attention (Sherratt & Bryan, 2019). Also interested in the effect of aging, Cannizzaro and Coelho (2013) examined the relationship between executive functions and story grammar in 46 neurotypical adults (18-98 years old). They reported that the number of story grammar elements was negatively correlated with age as well as with linguistic and non-linguistic measures of executive functions.

The purpose of the current study was to extend the findings of our recent study (Schneider et al., 2021), which sought to investigate the neural correlates of macrostructural measures in middle-low to low SES adults with a stroke in the LH or in the RH as well as in individuals with no brain damage. The aims of the present study were twofold. The first aim was to determine whether patients with a stroke in the LH or in the RH without major persistent language impairments differ from participants with no brain damage for macrostructural processes in oral narrative discourse production. Based on Barker et al. (2017), it was expected that: 1) patients with an LH stroke would have a lower performance in the more "local" macrostructural variable, or within-sentence processes, namely, the index of lexical informativeness (%) as compared to the other two groups and 2) individuals who suffer from a stroke in the RH would have a lower performance in the more "global" macrostructural variables, such as global coherence, macropropositions, and narrativity as compared to the other two groups. Based on previous studies (e.g., Andreetta et al., 2012; Barker et al., 2017; Marini, Carlomagno, et al., 2005; Sherratt & Bryan, 2019; Stockbridge et al., 2019), we also expected that lower performance in terms of cohesion would be observed in both LH and RH as compared to the control group. The second aim was to determine whether there was a relationship between the macrostructural measures and cognitive and sociodemographic measures. Based on a large body of evidence (e.g., Boucher et al., 2020; Fergadiotis & Wright, 2016; Herbert et al., 2008; Richardson et al., 2018), we expected to find correlations between macrostructural variables (and more specifically with informativeness) and naming accuracy. We also expected that correlations would be found

between macrostructural measures (and more specifically coherence and narrativity) and executive functions in story grammar (Barker et al., 2017; Mozeiko et al., 2011; Wright et al., 2014). Finally, we expected an effect of RWH in measures of oral discourse production as reported with word-level tasks (Pawlowski et al., 2012). Finally, we expected that SES would be associated with macrostructural measures of discourse production as reported with the quality of content and discourse productivity (Snow et al., 1997; Yorkston et al., 1993) and with cohesion (Coelho, 2002).

Materials and Methods

Participants

Thirty-one (31) participants diagnosed with an ischemic stroke in the LH (n=15) or RH (n=16) took part in the study. Demographic and clinical variables of participants with a stroke are presented in Table 1. The study took place at least four months (LH mean = 14.6 ± 7.9; RH mean = 10.8 ± 5.4) after stroke onset. No criteria concerning lesion size were adopted. All participants were diagnosed by a neurologist and a radiologist at a hospital that treats patients from the public health system in a metropolitan area in a southern state in Brazil. All participants were native speakers of Brazilian Portuguese and completed their evaluation in their native language. Exclusion criteria included 1) moderate to severe language impairments, 2) history of major psychiatric disorders, 3) learning disabilities, 4) severe and uncorrected self-reported perceptual deficits, 5) additional neurological diagnoses, 6) left-handedness or ambidexterity which was assessed using the Edinburgh Handedness Inventory (Oldfield, 1971), 7) < 2 years or > 13 years of formal education, and/or 8) bilingualism. The participants of the present study include the subset of the participants who also underwent magnetic resonance imaging (Schneider et al., 2021).

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Sixteen (16) age- and schooling-matched neurotypical controls were recruited in community centers. As reported in Table 1, the control group was unbalanced with both clinical groups regarding the sex variable because the recruitment of healthy men is more challenging in Brazil compared to that of women. Similarly, controls were native speakers of Brazilian Portuguese. In addition to the exclusion criteria used with the clinical patients, the exclusion criteria included: 1) previous stroke and 2) a score on the Mini-Mental State Examination (MMSE) lower than the age and educational specific cut-off score adapted for the Brazilian population (Brucki et al., 2003): illiterate = 20 points; 1-4 years of education = 25 points; 5-8 years of education = 26.5 points; 9-11 years of education = 28 points; ≥11years of education = 29 points). Full written consent was obtained from all subjects. The present study is an extension of a previous study (n=30 participants) that investigated the neuroanatomical correlates of macrostructural aspects in an unilateral stroke (Schneider et al., 2021). The study was approved by the Ethics Review Board of the Pontifical Catholic University of Rio Grande do Sul (Project # 51099415.6.0000.5336).

Materials and procedures

Neuropsychological assessment

The participants underwent a short neuropsychological assessment using the Digit and Word span working memory tests (Instrumento de Avaliação Neuropsicológica Breve - NEUPSILIN, Fonseca et al., 2009), a short naming task (Montreal-Toulouse-Brasil [MTL-BRASIL], Parente et al., 2016) consisting of 12 nouns and 3 verbs (maximum of 2 points per stimulus, for a total of 30) represented in black and white pictures, and a free verbal fluency task (Bateria Montreal de Avaliação da Comunicação Breve (MAC-Breve); Casarin et al., 2014). The free verbal fluency task investigates the ability to freely explore lexical-semantic memory during the evocation of words without a semantic or orthographic restriction. Participants also completed a questionnaire developed by the Brazilian Market Research Association (*ABEP - Associação Brasileira de Empresas de Pesquisa*) to capture their

socioeconomic status (SES). This questionnaire allows for the calculation of an SES score based on the education level of the head of the household and other household characteristics including the number of certain consumer goods and amenities.

Participants were further characterized by the administration of a questionnaire of RWH adapted from Pawlowski et al. (2012). The questionnaire evaluates the weekly frequency of reading different types of printed and digital material, such as magazines, newspapers, books, social media, and the weekly frequency of writing notes, text messages, literary and/or non-literary texts. Frequency ratings of both reading and writing habits were scored using a 4 point-scale: daily (4 points); a few days a week (3 points); once a week (2 points); rarely (1 point), and never (0 points), with a maximum score of 16 points for each modality (reading and writing). For the patients we considered their reading and writing habits just before the stroke onset.

Narrative discourse assessment

All participants were asked to produce three oral narratives based on three picture-sequence stories supported by black and white pictures: (1) *The dog story* (Hübner et al., 2019), (2) *The car accident* (Joanette et al., 1995), and (3) *The cat story* (Ulatowska et al., 1981). The three stories present a sequence of six or seven scenes and have equivalent length and narrative structure (Adam, 2008) in terms of an introductory setting, a complication and a resolution. The stories were randomly presented to participants to balance the order of presentation. The examiner verbally provided these instructions (in Brazilian Portuguese, here translated into English) before the presentation of the first story: *'I'm going to show you a story based on a series of pictures. Each picture represents a moment in the story, which has a beginning, a middle and an end. I will ask you to take a good look at the pictures and to try to understand the story. I'm going to ask you to tell me this story as if you were going to tell it to a friend. (Wait a few seconds). Are you ready? Can we start?'* Participants were allowed to look at the pictures during narration and were encouraged to pay attention to all aspects of the stories.

Transcriptions

Sequential narratives were audio-recorded using a Sony Digital Flash Voice Recorder (ICD-PX312) and further transcribed. The procedures for transcription, inter-rater reliability, and analysis have been previously reported (Schneider et al., 2021). Briefly, audios of each discourse sample were imported and transcribed using the software Transcribe by an experienced linguist (FS) and a language student who were both blind to group assignment using the *Norma Linguística Urbana Culta* (Cultured Linguistic Urban Norm, NURC) standards (Castilho & Pretti, 1986). Utterance segmentation was conducted using a combination of acoustic, semantic, grammatical, and phonological criteria that demonstrated high reliability scores (Andreetta & Marini, 2014). For instance, according to the acoustic criterion, the segmentation of an utterance is made when a pause, empty or full, is clearly identified. For example, in the following sequence: *It was a man with the … [silent pause of 5 seconds] with the little girl,* a clear empty pause was perceived and it was thus segmented in two utterances. According to the phonological criterion, a segmentation is applied when a word is interrupted or incomplete. To be included in the count, the words had to be intelligible in the context but they did not have to be precise, relevant, or informative in relation to the stimulus. Phonological paraphasias, for instance, cannot be entered in the word count. The number of words was verified using the Transcribe software and revised using the statistics provided by Word (Version 2005/Microsoft 365).

Analyses

Two raters blinded to group assignment (RH, LH group and controls) scored the participants' narrative oral productions based on macrostructural measures included those pertaining to the quality of the narrative organization (i.e., cohesion, global coherence, macropropositions, and narrativity) and the level of informativeness (i.e., index of lexical

informativeness). Each macrostructural discourse measure is reported after combining the three stories together.

Cohesion

Cohesion refers to the lexico-grammatical and semantic links among continuous sentences that are crucial for the interpretation of the meaning. Cohesive ties were identified across the three categories proposed by Antunes (2005): reference (or “reiteration”, in the original), association, and connection. A referential tie links one word to another that is equivalent using grammatical substitution, repetition, lexical substitution, and ellipse. An association tie, also known as lexical cohesion, links the meaning between nouns, adjectives, and verbs by the selection of vocabulary. A connection tie, also known as conjunction, extends the meaning between the different parts of the text (i.e., between T-units, sentences) using prepositions, conjunctions, and adverbs (please see Schneider et al., 2021 for examples of the different cohesion relations). Cohesion was scored by counting the number of occurrences of cohesion ties. This number was divided by the number of utterances (parts of the narrative produced by the participant) and multiplied by 100.

Global coherence

Global coherence (Kintsch & van Dijk, 1978) refers to the speaker’s conceptual organization. Complete propositions related to the topic were given a score of 1.0, incomplete propositions related to the topic were scored .5 and propositions containing errors of global coherence, were score 0. We added an intermediate .5 point score for congruent but incomplete propositions in order to adjust the scoring to the characteristics of the age and low education level of our sample. The percentage of global coherence was calculated by dividing the sum of these scores by the total number of propositions produced and multiplying this value by 100 (adapted from Andreetta et al., 2012).

Errors of global coherence included tangential propositions, incongruent propositions, propositional repetitions (Christiansen, 1995) or simple fillers (Andreetta et al., 2012). A tangential proposition derails in the flow of discourse with respect to the content of the previous propositions and can include personal comments. *For instance, one participant*

produced the following sequence during the description of the cat story: 'oh, that happened to me once/ a Kitten climbed a pole/' (ah isso aconteceu comigo uma vez/ um gatinho subiu num poste, in Portuguese). Here, the first proposition was scored as tangential, as the person added personal information to the story. Propositions were considered as incongruent when the person added information that was not present in the stimulus. For example, one participant produced the following sequence during the description of the dog story: [...] (they) are in a bed ([...] ("tão" numa cama, in Portuguese). Here, the proposition was scored as incongruent as the person added information that is not part of the story.

Macropropositions

Each narrative was also divided into a set of definite *macropropositions* identified by independent judges, including story setting, scenario, complication, and resolution (Van Dijk, 1980; Van Dijk & Kintsch, 1983). The dog story contained a maximum of six macropropositions, while the car accident and the cat story each contained five (see Supplementary Material 1 of (see Supplementary Material 1 of Schneider et al., 2021 for the list of the macropropositions used in each story). The number of macropropositions produced by each participant was divided by the total number of narrative macropropositions and multiplied by 100.

Narrativity

Narrative organization assessment also included the *narrativity* measure, which evaluates how narratives are orally produced. In other words, the narrativity score encompasses the observance of the sequence of the facts occurring in the story. Narrativity was measured using based on BALE (Hübner et al., 2019) representing the sum of four items: presence or not of a narrative sequence, predominance of scene description, inclusion of intrusive/non-existent information in the story, character recognition., the predominance of narration (as opposed to scene descriptions), the non-inclusion of tangential or inexistent aspects, and the characters' recognition (Hübner et al., 2019). One

point was attributed to each criterion, for a maximum of four points for each story. Thus, higher narrativity scores reflect better performance.

Lexical informativeness

Lexical informativeness refers to content and functional words that are appropriate from a phonological, grammatical, and pragmatic point of view (Andreetta & Marini, 2015). Informative nouns and verbs were extracted using AntConc 3.4.4w (Anthony, 2016), a freeware which has been adapted to Brazilian Portuguese. The index of lexical informativeness was calculated by dividing the number of informative nouns and verbs produced by each participant by the total number of words produced and multiplied by 100 (Andreetta & Marini, 2015; Marini, Andreetta, et al., 2011; Marini, Carlomagno, et al., 2005).

Our previous study (Schneider et al., 2021) which was conducted in a subset of the participants of the present study tested inter-rater reliability (IRR) using two-way random effects intraclass correlation coefficients (ICC), a statistical metric commonly used to assess inter-rater reliability. ICC values range from 0 to 1 and can be categorized into four levels of test-retest reliability: excellent (ICC > .75), good (ICC = .60 to .74), fair (ICC = .40 to .59), and poor (ICC > .40) (Fleiss et al., 2003). Based on this categorization, the degree of reliability between raters was excellent for cohesion (ICC = .907; 95% confidence interval (CI) = [.589, .979]) and macropropositions (ICC = .750; 95% CI = [-.108, .944]), good for narrativity (ICC = .608; 95% CI = [.231, .800], and fair for coherence (ICC = .497; 95% CI = [-1.229, .887]). ICCs were not calculated for the index of lexical informativeness as the informative words were extracted by a freeware (Anthony, 2016).

Statistical analyses

Cohesion and the index of lexical informativeness showed a normal distribution according to the Shapiro–Wilk normality test ($p > .05$). Total number of words, total number of utterances, coherence, macropropositions, and narrativity showed a non-normal

distribution according to the Shapiro–Wilk normality test ($p < .05$). Analyses of variance (ANOVAs) were conducted for variables with a normal distribution, and a non-parametrical Kruskal–Wallis test with Bonferroni post-hoc comparisons was conducted for the variables with a non-normal distribution.

In a smaller sample of participants, we reported significant correlations between narrativity and naming, digit span, and word span (Schneider et al., 2021). Few other studies explored the correlational relationship between macrostructural measures and socio-demographic and cognitive measures. Among those, Rogalski et al. (2010) reported stronger correlations between cognitive functions and global coherence than with local coherence. Previous studies have also shown that story grammar (Mozeiko et al., 2011) and global coherence (Barker et al., 2017; Wright et al., 2014) were correlated with measures of executive function, and that cohesive ties were positively correlated with verbal fluency (Sherratt & Bryan, 2019). Exploratory correlations were thus performed to assess the possible association between sociodemographic and neuropsychological variables and the macrostructural variables. Based on previous findings, correlations with macrostructural measures were performed between the macrostructural measures themselves as well as with two sociodemographic variables, SES and RWH, and three neuropsychological variables, naming, verbal fluency (i.e. executive functioning) and digitspan (i.e. working memory). Most correlations were conducted using Kendall's tau correlation, as most variables showed a non-normal distribution according to the Shapiro–Wilk normality test ($p < .05$). Only six correlations were conducted using Pearson's r correlation (cohesion and lexical informativeness; cohesion and SES; lexical informativeness and SES). A Bonferroni correction was made for multiple comparisons, resulting in an alpha level of .005 for each family of tests.

Results

Participants

Table 2 presents mean sociodemographic descriptive data and neuropsychological results for participants with a LH stroke, participants with a RH stroke and age-matched healthy participants. One-way ANOVAs showed that there was no significant difference in age and SES among the three groups. Time of stroke onset was also comparable between the LH and RH groups. Non-parametrical Kruskal–Wallis tests showed that there were no significant differences in education and RWH among the three groups.

Regarding the neuropsychological assessment, a significant effect of group on the MMSE (H(2) = 12.4, *p* = .002), naming (H(2) = 6.82, *p* = .033), and word span (H(2) = 10.10, p = .006) was found, for which the LH patients had a lower performance than healthy controls according to the post-hoc comparisons. A significant effect of group on free verbal fluency (H(2) = 6.63, *p* = .036) was found. Post-hoc comparisons showed that LH and RH patients had a lower performance than healthy controls. No group effect was found for the digit span.

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Insert Table 2 approximately here

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Behavioral Results

Mean and standard deviations (mean ± SD) for each group are reported in Table 3 in addition to the statistical values of the tests. The distribution of the data is illustrated in Figure 1. There was no significant effect of group in terms of total number of words (H (2) = 2.4, *p* = .326) and total number of utterances produced in the three stories combined (H (2) = 4.4, *p* = .110). A significant effect of group on the cohesion score was found (F (2,45) = 11.0, *p* = .001), for which the LH patients had a lower performance than healthy controls according to the post-hoc comparisons.

A significant effect of group on the global coherence score was found (H (2) = 10.5, *p* = .005) with post-hoc comparisons showing that patients with an RH stroke had a lower performance than healthy controls.

Similarly, a significant effect of group on the macropropositions score was found (H(2) = 6.4, *p* = .040) and post-hoc comparisons showed that patients with an RH stroke had a lower performance than healthy controls.

A significant effect of group on the narrativity score was also found (H(2) = 6.2, *p* = .045), but none of the post-hoc comparisons were significant.

No group effect for the index of lexical informativeness was found.

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Insert Table 3 approximately here

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Insert Figure 1 approximately here

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Exploratory correlations were performed to assess the possible association of the macrostructural variables and sociodemographic and cognitive variables. Correlations are reported in Table 4. Unsurprisingly, the most significant correlations were found between the macrostructural measures themselves. Moderate to strong correlations were found between all macrostructural variables. The strongest correlations were found with narrativity (cohesion, τ=.55, *p* <.001; coherence τ=.75, *p* <.001; macropropositions τ=.68, *p* <.001; lexical informativeness τ=.64, *p* <.001). Higher narrativity scores were associated with higher scores in the other macrostructural variables. In addition, higher scores in each macrostructural variable were associated with a higher score in the four other macrostructural variables.

As hypothesized, regarding the neuropsychological tasks, the strongest correlations were found with naming. Moderate correlations were found with naming and macropropositions **(**τ=.43, *p* <.001), narrativity (τ=.46, *p* <.001), and lexical informativeness (τ=.50, *p* <.001), whereas weak correlations were found with cohesion (τ=.34, *p* =.002) and

coherence (τ=.39, p <.001). In other words, a better naming performance was associated with better macrostructural skills. Also as expected, weak to moderate correlations were found with pre-stroke reading and writing habits and all five macrostructural variables. That is, greater RWH were associated with better macrostructural skills, and more strongly with narrativity (respectively τ=.42, p <.001 and τ=.38, p =.001). Weak to moderate correlations have also been found with verbal fluency and digit span (working memory). Interestingly, a moderate correlation was found between lexical informativeness and verbal fluency (τ=.43, p <.001).

Discussion

The present study extends the results of our preliminary study (Schneider et al., 2021) in a larger group of participants with middle-low to low SES and low levels of education, in which we investigated macrostructural processes in oral narrative production. As expected, patients with a stroke in the LH presented lower scores for lexical informativeness, but the difference between the three groups was not significant. Individuals with a stroke in the RH presented a lower performance in terms of global coherence and macropropositions (the more “global” macrostructural variables) as compared to controls but not as compared to individuals with a stroke in the LH. Both groups of individuals with a stroke also presented lower performance in terms of cohesion as compared to the control group. The second aim was to determine whether there was a relationship between the macrostructural measures and cognitive and sociodemographic measures. As expected, similar to previous work but with different discourse measures (e.g., Barker et al., 2017; Fergadiotis & Wright, 2016; Mozeiko et al., 2011; Wright et al., 2011, 2014), we showed the relationship between cognitive processes and macrostructural processes, more importantly regarding naming and executive functions. Finally, weak associations were found between the macrostuctural measures and SES but stronger associations have been found with RWH. Taken together, our results highlight the importance of investigating discourse processing using a multifactorial approach and point to the engagement of both RH and LH

in macrostructural aspects in oral narratives, with the RH involved in more global aspects, including global coherence and macropropositions.

Consistent with previous evidence (Andreetta et al., 2012; Barker et al., 2017; Davis et al., 1997; Ellis et al., 2005; Geranmayeh et al., 2017; Stockbridge et al., 2019), patients with an LH stroke showed lower performance in the more “local” macrostructural variables, responsible for cohesive ties within and among sentences, as compared to controls. Unlike in our previous study (Schneider et al., 2021), in which each group had 10 participants, the increase in the number of participants in the present study allowed us to reveal a significant difference in terms of cohesion between RH stroke patients and controls, although with a lower significance than between LH patients and controls. This result is in line with previous studies (Marini, Carlomagno, et al., 2005; Sherratt & Bryan, 2019; Stockbridge et al., 2019), which associated cohesion impairment to a stroke in the RH. Still, LH participants produced a lower proportion of cohesive ties per utterance than RH participants, as in the study of Uryase et al. (1991), though the difference between the clinical groups was not significant considering the large intragroup variability. One potential confound that could explain the differences from previous studies is the low level of SES and education of the participants in the present study. Low SES, which has an impact on stroke outcomes (Song et al., 2017), has been associated with reduced cohesive adequacy (Coelho, 2002) as well as reduced content and discourse productivity (Snow et al., 1997; Yorkston et al., 1993). Moreover, most studies reported on participants with a higher level of education. For instance, Coelho (2002) investigated the impact of SES in a group of participants who had between nine (9) and 14 years of education, whereas the participants in the present study had between two (2) and 13 years of education and had a low to middle-low SES.

Still considering the more local processing, we also postulated that the index of lexical informativeness would be lower for the LH group. Although both clinical groups had lower scores as compared to controls, the intergroup differences did not reach significance. In contrast, Agis et al. (2016) reported a significant difference between both LH and RH,

assessed within 48 hours post-stroke onset, compared to a group of healthy controls with measures of content units (Yorkston & Beukelman, 1980) elicited by the Cookie Theft picture from the BDAE-3 (Goodglass et al., 2001). Yet, both clinical groups did not differ from each other. This contrasting result could be interpreted in three ways. The first and most probable interpretation is the difference in the timing of the assessment between the two studies: 48 hours post onset (i.e., acute phase of recovery) in Agis et al. (2016) versus at least four months post onset (i.e., late sub-acute/chronic phase of recovery) in the present study. Important changes can occur between the acute phase and the late sub-acute/chronic phase. More specifically, participants from the clinical groups almost certainly presented language improvements between the acute phase and the time of data collection, which can explain the differences between the two studies. Second, the nature of the tasks (i.e., single-picture description versus sequence-picture description) and variables (i.e., content units (CU) compared to a published list of CU produced by healthy controls versus the number of informative nouns and verbs produced by the participants) in the studies could also explain the differences. Third, the large variability in our clinical groups may have led to the lack of statistical differences in the groups' comparisons. Finally, now considering the more "global" macrostructural variables, the patients in the RH group differed from the controls in global coherence and macropropositions, while the difference in narrativity did not survive post-hoc analyses. The important role of the RH in more global processing has been well established (Karaduman et al., 2017). To date, global coherence is one of the most studied variables in macrostructural processing in narratives (Ellis et al., 2016). Unsurprisingly, and consistent with previous evidence, global coherence was significantly affected in RH compared to healthy controls (Barker et al., 2017; Bartels-Tobin & Hinckley, 2005; Davis et al., 1997; Marini, 2012). Nonetheless, the present study adds evidence because relatively few studies have compared patients with unilateral LH and RH stroke individuals.

The second and novel aim of the present study was to determine whether there would be a relationship between the macrostructural measures and cognitive and

sociodemographic measures. The correlational analyses showed the intrinsic relationship between the macrostructural variables in the present study that contribute to a successful oral narrative. More specifically, all macrostructural variables, including those more local (i.e., cohesion) and global (i.e., coherence and narrativity) ones, were correlated with each other, demonstrating the complexity of discourse processing and the interdependency of different levels of processing for successful discourse production. This result contrasts with Rogalski et al. (2010), who reported that local and global coherence did not correlate but probably due to a lack of statistical power, as suggested by the authors (n=13 participants with a stroke and n=12 controls, r_s=.52, p = .07). In our study, narrativity, here encompassing the ability to maintain the connection between scenes while narrating a story (as opposed to describing it), to follow the main stream of the plot without including extraneous or tangential information, and to observe the characters' roles, was the variable most strongly correlated to the other macrostructural variables (cohesion, coherence, macropropositions, and lexical informativity). Due to the novelty of this measure in picture-sequence descriptions, we suggested in our previous study (Schneider et al., 2021) that we should further investigate the association between narrativity and story planning and monitoring as executive tasks. As expected, narrativity was also the measure that most strongly correlated with measures of executive functions, naming, and RWH. The ability to detect the sequence of the narrative structure, with its causal implications, is crucial for successful storytelling, but may be difficult to assess by using single-picture description (Bryant et al., 2016). Thus, these results support the relevance of using a picture-sequence oral narrative to investigate oral discourse production. In fact, picture-sequence description has proven to be the best task for examining cohesion and its relation to other cognitive functions (i.e., attention and memory) (Sherratt & Bryan, 2019). This is not surprising considering the nature of widely used single-picture description tasks, such as the Cookie Theft from the Boston Diagnostic Aphasia Examination (Goodglass et al., 2001) and the Picnic scene from the Western Aphasia Battery (Kertesz, 2006), as the different elements of the picture do not necessarily have to be linked, which reduces the use of linguistic markers to connect the different elements (Marini, Boewe, et al., 2005).

Consistent with previous findings (e.g., Boucher et al., 2020; Covatti Malcorra et al., 2021; Fergadiotis & Wright, 2016; Herbert et al., 2008; Richardson et al., 2018), better naming ability was associated with better performance at the macrostructural discourse level. There were weak to moderate correlations between all macrolinguistic measures and verbal fluency and digit span, indicating the role that these neuropsychological variables play in discourse oral production. Contrarily, Wright et al. (2014) reported that none of the cognitive measures (i.e., episodic memory, working memory, and attention) were correlated with global coherence in picture-sequence descriptions in both the younger and the older groups of participants. These divergent results could have occurred because our participants had lower SES and education than their participants (mean of 15.6 years of education for the older group). The task may have posed higher demands on executive functions (measured by verbal fluency) and on working memory while mentally organizing the macrostructure of the narratives to be told. We postulate that the more reduced automated skills, necessary to deal with the discourse task, as a consequence of lower education and of the time that passed after leaving school, have an impact on the automatic recruitment of cognitive abilities, such as working memory and executive functions. Another possible explanation is how coherence was calculated in both studies. In the present study, global coherence was calculated by giving a score of 1 point to each complete proposition related to the topic and a score of .5 point for an incomplete proposition, whereas Wright et al. (2014) used a 4-point scale for each c-unit and averaged the coherence score of each discourse type. Although these findings are interesting and suggest future research directions, we have not identified a true relationship between naming (and any other cognitive abilities) and macrostructural abilities. Further studies with larger sample size are required to test how these abilities are associated.

Finally, RWH were significantly correlated with all five macrostructural variables, but more importantly with narrativity. This result makes an interesting contribution to the field of

studies on the impact of sociodemographic variables on discourse production. Our sample was composed of low to middle-to-low SES—normally associated with low education and low reading and writing habits—which represents the majority of adults and older adults assisted by the public health service in underdeveloped and developing countries, as it is the case in Brazil, as well as in immigrant populations in developed countries. Groups were matched for years of formal education, and they all had relatively low levels of education. Yet, the present results suggest that RWH are associated with oral discourse production at the macrostructural level. A growing body of evidence recognizes the protective action of cognitively stimulating activities, including reading and writing habits (e.g. Chang et al., 2021; Gallucci et al., 2009; Wilson et al., 2002). Reading engages several cognitive abilities, such as working memory, selective attention, semantic knowledge, and episodic memory, and therefore stimulates several brain areas (Sörman et al., 2018). Research with cognitively healthy adults and older adult participants has already shown that RWH may compensate for lower levels of education in cognitive and neuropsychological assessment, including language (Cotrena et al., 2016; Pawlowski et al., 2012). Earlier in life, reading abilities are strongly related to the level of education (Chang et al., 2021). However, the results obtained in students developing their reading and writing skills are probably not generalizable to adults (Locher & Pfost, 2020). Reading and writing skills have a lifetime development, which means that they can improve not only in younger age but also in adulthood. RWH may be related not only to the level of education, but also to the type of occupation, which may demand various levels of reading and writing engagement. Interesting findings from an intervention study also showed that the increase of cognitive abilities such as reading in older adults improved the speed of processing (Tesky et al., 2011). Nonetheless, it is important to note that RWH have generally been associated with the level of education and to cognitive abilities (as measured with childhood IQ) (Sörman et al., 2018). The present study cannot distinguish the specific role of education, SES, and RWH as they most probably interact altogether to shape cerebral, cultural, social, linguistic, and cognitive development (Ardila et al., 2010; Huettig et al., 2018; Tessaro et al., 2020). Despite its

relevance, this is, to our knowledge, the first time that RWH, as well as SES, have been correlated with macrostructural aspects in oral discourse, more specifically in oral narrative production in stroke populations. Taken together, these results point to the need for taking RWH and SES as important variables to consider when studying stroke outcomes, in various types of language tasks, in various languages. Thus, it reinforces the need for further studies focusing on the impact of SES in both neurotypical and clinical populations with a wider range of SES and educational levels, and using multiple language tasks and including languages other than English. From a clinical point-of-view, RWH and SES are commonly considered as comparable to the level of education. In fact, the level of education is almost systematically considered when assessing a patient in speech-language pathology, as most language batteries have different normative data for lower and higher levels of education. The present results suggest that clinicians should also consider questioning their patients about their SES and RWH as it might also have an impact on their discursive abilities. Investigating the behavioral and neurobiological mechanisms in these populations makes important contributions to future research and clinical outcomes because they represent most of the people in the world who are living in mainly underdeveloped countries.

It should be stated that the current study has several limitations. The first relates to the small sample size, which makes it difficult to generalize the present results to all patients who underwent LH or RH stroke with low levels of education and SES. Another aspect to consider is the gender differences among the three groups. In Brazil, recruitment of controls, especially men, is very challenging. Consequently, the control group is unbalanced with both clinical groups regarding the sex variable. We acknowledge that it would have been optimal to have matched groups on the sex variable, considering the potential impact of sex on cognition. For instance, Munro et al. (2012) reported a difference in cognitive test performance between genders in a large sample of elderly individuals, suggesting that the influence of gender on cognition persists in late life. However, a more recent review (Jäncke, 2018) stated that most of the differences between genders are not large enough to support

the hypothesis of sexual dimorphism in terms of anatomy, brain function, cognition, and behavior. Instead, the author suggests that many brain and cognitive traits are modulated by the environment, culture, and practice, along with other influences.

Conclusions

This study contributes to the existing body of evidence regarding macrostructural aspects in discourse production by comparing LH and RH stroke populations to controls, corroborating the role of the LH in more local processing and the RH in more global aspects of discourse, and also corroborating the interplay between discourse and neuropsychological measures. Moreover, this study highlights the importance of taking into consideration sociodemographic profiles of participants, such as education (Ardila et al., 2010; Huettig et al., 2018; Tessaro et al., 2020), SES and RWH, as important variables influencing the performance in discourse production; specifically, to what concerns oral narratives, with implications for clinicians, educators and public health and education policy makers.

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Table 1. Demographic and clinical variables of participants with a left hemisphere lesion (upper part).

Participant	Sex	Age	Education	Lesion location					Time post-onset (months)	Initial NIHSS score	Persistent Communication impairments
				Frontal	Temporal	Parietal	Occipital	Sub-cortical			
Patients with LH lesion											
1	M	72	7	X				X	12	7	yes
2	F	76	5	X					14	5	no
3	M	59	11					X	7	5	no
4	M	76	11					X	24	11	no
5	M	65	5		X			X	11	4	no
6	M	56	10	X					11	8	no
7	M	57	11			X			14	2	no
8	M	68	8	X	X	X	X		5	6	yes
9	M	74	3					X	8	10	no
10*	M	70	5						24	6	no
11	F	59	6			X			6	3	no
12	M	66	4	X					7	n/a	no
13	F	76	5				X		12	3	no
14	M	50	8	X		X			11	1	no

15	F	71	5					X	16	0	no
Patients with RH lesion											
201	M	70	9					X	12	7	no
202	F	66	11					X	7	6	no
203	F	79	3					X	7	9	no
204	M	63	11	X		X			16	5	no
205	F	63	8	X					8	4	no
206	F	79	4	X		X	X		11	14	no
207	F	71	6						17	8	no
208	M	57	11					X	4	1	no
209	F	50	8	X				X	5	2	no
210	M	78	5	X		X		X	18	13	no
211	M	80	5				X		4	8	no
212	F	65	3				X		20	7	no
213	M	63	9					X	14	0	no
214	M	57	5		X				9	n/a	no
215*	M	59	7						6	7	no
216	M	56	13					X	16	11	no

*For this two participants, we only have the report from the radiologist which says that there was a lesion in the territory of the medial cerebral artery. There were no specifications regarding the more specific location of the lesion. F = Female; M = Male; n/a = not available

Table 2 – Mean sociodemographic descriptive data and neuropsychological results for participants with a LH stroke, participants with a RH stroke and age-mat
healthy participants.

	LH n=15			RH n=16			Controls n=16			Statistics
Sociodemographic data										
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**	
Age (years)	66.3	8.4	50-76	66.0	9.4	50-80	65.4	8.7	51-79	F(2,45) = .05, p=.954
Education (years)	6.9	2.7	3-11	7.4	3.1	3-13	7.1	3.8	2-13	H(2) = .33, p=.848†
Sex	3M, 12F	-	-	7M, 9F	-	-	1M, 15F	-	-	-
Time Post-stroke	14.6	7.9	5-30	10.8	5.4	4-20	-	-	-	t=2.38, p=.134
Socioeconomic status (SES)	26.3	7.0	17-37	24.9	6.4	12-36	26.4	7.2	15-38	F(2,45) = .19, p=.910
Reading habits (pre-stroke)	4.8	3.4	0-11	6.1	4.0	2-15	8.2	4.8	1-16	H(2) = 3.90, p=.143†
Writing habits (pre-stroke)	1.7	2.4	0-7	3.7	4.2	0-16	4.7	4.0	0-12	H(2) = 5.81, p=.055†
Neuropsychological assessment										
Mini-mental state examination (/30)	23.5	3.5	16-29	25.6	3.4	20-30	27.9	2.1	23-30	H(2) = 12.4, p=.002†[a]
Naming subtest (MTL-Brasil; /30)	25.8	5.6	8-30	27.6	2.8	20-30	28.9	1.8	23-30	H(2) = 6.82, p=.033†[a]
Free verbal fluency (MAC-Breve; no maximum)	25.4	20.1	0-67	25.7	15.8	2-63	45.2	22.7	9-89	H(2) = 6.63, p=.036†[a,b]
Digitspan	9.8	3.3	3-16	9.0	2.4	6-14	11.6	5.3	7-27	H(2) = 3.10, p=.212†
Wordspan	8.3	5.7	0-18	10.0	5.0	3-19	14.3	3.9	8-19	H(2) = 10.10, p=.006† [a]

LH= left hemisphere stroke patients; RH= Right hemisphere stroke patients; M= Male; F= Female;
SES = socioeconomic status as calculated by a questionnaire developped by Associação Brasileira de Empresas de Pesquisa in 2015: Class A = 45 - 100 points, B1 = 38 – 44 points, B2 = 29 - 37 points, C1 = 23 - 28 points, C2 = 17 - 22 points, D-E = 0 – 16 points)
† Non-parametric test statistics reported because this measure showed a non-normal distribution.
Posthoc statistics: [a] LH significantly different from controls <.01; [b] RH significantly different from controls <.01

Table 3. Mean behavioral results for participants with a LH stroke, participants with a RH stroke and age-matched healthy participants.

	LH n=15		**RH n=16**		**Controls n=16**		***Statistics***
	Mean	SD	Mean	SD	Mean	SD	
Cohesion[1]	55.4	31.8	80.1	39.8	109.3	23.9	$F(2,45) = 11.0$, $p<.001$[a,b]
Coherence[2]	43.8	32.1	39.1	20.1	66.1	13.1	$H(2) = 10.5$, $p=.005$[c]
% Macropropositions[3]	46.5	35.6	42.6	22.4	65.2	22.5	$H(2) = 6.4$, $p=.040$[b]
Narrativity (max. = 12)	5.9	4.5	6.7	3.8	9.4	3.0	$H(2) = 6.2$, $p=.045$
Index of lexical informativeness[4]	17.1	10.7	18.6	7.9	23.6	7.1	$F(2,45) = 2.1$, $p=.137$

LH= left hemisphere stroke patients; RH= Right hemisphere stroke patients.

[1] Cohesion = #cohesion ties/# utterances * 100

[2] Coherence = #propositions/# utterances * 100

[3] % Macropropositions = #macropropositions/#total macropropositions * 100

[4] Index of lexical informativeness = # information units/#words * 100

Posthoc statistics: [a] LH significantly different from controls <.005; [b] RH significantly different from controls <.05; [c] RH significantly different from controls <.005

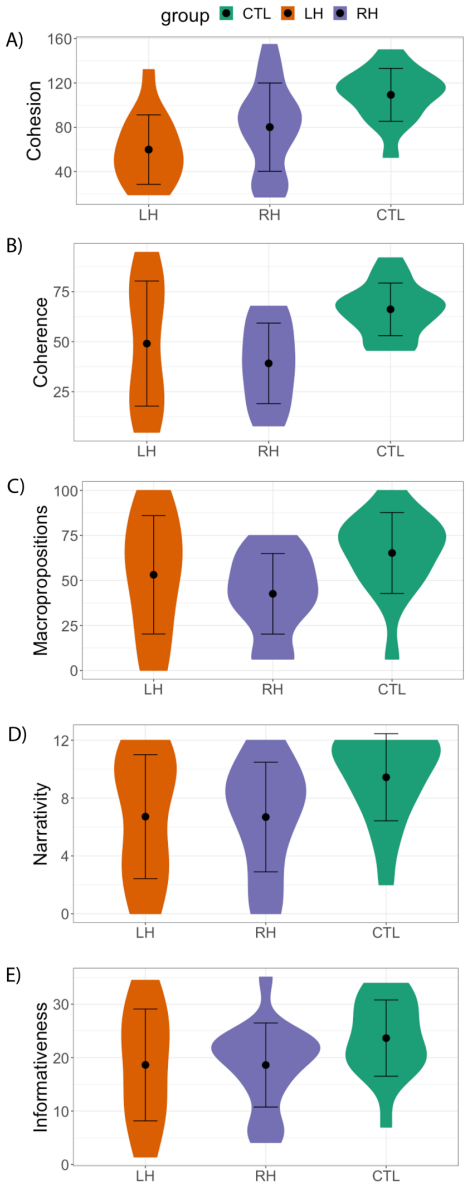
Table 4. Correlations between discursive variables, sociodemographic and cognitive variables.

Variables	2	3	4	5	6	7	8	9	10	11	12
1. Cohesion	.52***	.45***	.55***	.43[§] ***	-.11[§]	.27[§]	.33**	.35***	.34**	.27*	.33**
2. Coherence		.65***	.75***	.54***	-.02	.21*	.27*	.27*	.39***	.30**	.37***
3. Macropropositions			.68***	.46***	-.06	.15	.30**	.36***	.43***	.32**	.26*
4. Narrativity				.64***	-.08	.23*	.42***	.38***	.46***	.34**	.41***
5. Lexical informativeness					-.26[§]	.25[§]	.32**	.32**	.50***	.43***	.26**
6. Age						-.11[§]	-.15	-.03	-.12	-.08	-.14
7. Socioeconomic status (SES)							.07	.17	.15	.26*	.22*
8. Reading habits								.35**	.29**	.19	.15
9. Writing habits									.31**	.26*	.10
10. Naming										.32***	.15
11. Verbal fluency											.23*
12. Digitspan											

*** p< .001; ** p<.005; * p<.05, but did not survive the Bonferonni correction

[§] parametric tests have been used because both variables showed a normal distribution

Figure 1. Violin plots showing the distribution of the data and the probability density of the five macrostructural measures produced during three picture-sequence descriptions among individuals with a left hemisphere (LH) stroke, individuals with a right hemisphere (RH) stroke and neurotypical individuals. Black dots refer to the group mean and the pointranges represents one standard deviation.



Supplementary Material 2.

Reprint of Supplementary Material 1 of Schneider, F., Marcotte, K., Brisebois, A., Townsend, S.A.M., Smidarle, A.D.M., Loureiro, F., Franco, A. da R., Soder, R.B., Nikolaev, A., Marrone, L.C.P. & Hübner, L.C. (2021). Neuroanatomical Correlates of Macrolinguistic Aspects in Narrative Discourse in Unilateral Left and Right Hemisphere Stroke: A Voxel-Based Morphometry Study. 64 (5), 1650-1655. doi.org/10.1044/2020_JSLHR-20-00500

Macropropositions of narratives

The dog story (Le Boeuf, 1976)	
A boy sees a dog (lost puppy) on the street / sidewalk	scenario
The boy takes (decides to take) the dog home	scenario
The boy hides the dog in the wardrobe/closet	scenario
The mother finds the dog	complication
The mother asks the boy for some explanations / The boy begs the mother to keep the dog	complication
The mother allows the boy to keep the dog / The mother helps the child/the boy builds the dog house	resolution
The car accident (Joanette et al., 1995)	
A woman/mother drives the car and takes two children/her two children	scenario
The woman/mother parks the car/goes to an establishment and leaves the two children (the two small children) in the car	scenario
The boy gets into the driver's seat and moves the steering/lever of the car	complication
The car goes down the slope and hits a lamppost	complication
The woman/mother leaves the establishment and realizes what happened	resolution
The cat story (Ulatowska, Doyel, Stern, Haynes, & North, 1983).	
A girl/a daughter cries and asks a man/father for help because a cat/his cat is stuck on the branch of a tree	scenario
The man/father climbs the tree to remove the cat	scenario
The man / father leans on the branch and reaches the cat	complication
The man/father throws the cat from the tree towards the girl (the cat jumps towards the girl)	complication
The man / father gets stuck on the branch by his jacket and a fireman comes to rescue him	resolution